Transportation Costs for Industrial Minerals Produced in B.C.

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by

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1. Introduction

British Columbia has numerous deposits of "industrial minerals" or non-metallic minerals that are used in the construction industry and a variety of manufacturing processes. Only a fraction of those deposits have been developed to date and there is potential for substantial growth in this sector of the mining industry. The extent of that growth will be heavily dependent on transportation costs. Depending on market location, transportation can be a larger cost item than mining and processing costs and one of the main factors that determine whether B.C. products are competitively priced.

This report provides estimates of the cost of transporting industrial minerals to selected markets in North America and overseas countries. The analysis focuses on truck and marine transportation, although rail transport may be a competitive option in more distant North American markets.

Twelve minerals were selected for analysis:

- Perlite
- Mica
- Garnet
- Silica
- Crushed Aggregate
- Dimension Stone
- Olivine
- Bentonite
- Wollastonite
- Feldspar
- Nepheline Syenite
- Talc

Nineteen deposits or production sites have been selected for analysis, covering each of the twelve minerals and a range of geographic locations that extend from the Queen Charlotte Islands to the East Kootenays. Although a few of the deposits have been actively mined in the past, most would represent entirely new developments.

Finally a number of delivery points were selected as potential markets for each operation. In total, about 80 different transportation routes are considered in the analysis, each linking a mineral deposit with a potential market. Delivery points include centres across western Canada and the western United States as well as points as far east as Montreal and as far south as Texas. Japan, Korea and Hawaii are also considered as potential markets.

Transportation costs are developed in four stages in the remainder of the report. Chapter 2 describes each of the cases that have been selected for study and includes information on location of the deposits, potential markets, and product handling characteristics. Chapters 3 and 4 then describe the costing techniques used for truck and marine transportation, respectively. Finally, cost estimates for each case are presented in Chapter 5 and general conclusions are drawn in Chapter 6.

2. Representative Cases

Site Locations

Nineteen sites were selected for analysis, representing various degrees of accessibility. Those sites are listed below and are shown in Exhibit 1.

Case	Mineral		Location
1	Perlite	a.	Empire Valley, to the west of Clinton and the Fraser River.
		b.	Near Juskatla on Graham Island (Queen Charlotte Islands).
2	Mica		North of Chase, near the west shore of Adams Lake.
3	Garnet	a.	West of Penticton near the Apex Mountain ski resort.
		b.	North of Revelstoke, near Highway 23.
		c.	North of Revelstoke, near Highway 23.
4	Silica	a.	Near Longworth, on the north side of the Fraser River, to the east of Prince George.
	Silicon Carbide	b.	Prince George.
		c.	Kitimat.
5	Crushed Aggregate		South of Squamish on Howe Sound.
6	Dimension Stone	a.	North of Pemberton, near the Duffy Lake Road.
		b.	Immediately east of Squamish.
		c.	Finishing plant in Vancouver.
7	Olivine		Near Coalmont, to the north of Princeton.
8	Bentonite		At Hat Creek, between Lillooet and Cache Creek.
9	Wollastonite		North of Kelowna, near Fintry Point on the west shore of Okanagan Lake.
10	Feldspar		East of Vernon and Lumby near Highway 6.
11	Nepheline Syenite		North of Revelstoke, near Mica Creek.
12	Talc		East of Quesnel, off the road to Barkerville.

The location of these sites is shown in greater detail in Exhibits A.1 to A.9.

Access

Most of the sites are directly accessible by road, mainly over heavy-haul roads which were originally built for logging trucks.

Access to each site is described below.

1a. Perlite

The Empire Valley perlite deposit has been mined in the past and is accessible by two routes.

The first of these crosses the Fraser River on a load-restricted bridge at the Gang Ranch. The route then joins the Cariboo Highway north of Clinton. Because of weight restrictions on the bridge it is necessary to transport material across the Fraser in relatively light trucks, stockpile it on the east side of the River and reload into larger trucks. This double-handling system was used when the mine was active in the past.

An alternative route from Williams Lake avoids the load-restricted bridge but involves a longer haul for any southbound shipment. For shipments to Vancouver, for example, the Williams Lake route is about 180 kilometres longer than the Clinton route. This route is used on a regular basis to haul fuel to the Blackdome Gold Mine.

1b. Perlite

The perlite deposit near Juskatla is accessible by logging road, with three options for truck delivery to tidewater. The shortest route is a 10-kilometre haul over high-standard logging road to Juskatla, a MacMillan Bloedel logging camp located in Mamim Bay. Barge access is restricted by depth of water at the approach to Juskatla Inlet. (Water depth in the approach to the Inlet is about 2 metres at lowest normal tide, compared with a draft of about 3.5 metres for a loaded 3000-ton flat-deck barge.)

A second alternative is to extend the haul to Port Clements, again over high-standard logging road. This increases the length of haul by about 15 kilometres, but avoids restricted tug and barge access to Juskatla Inlet. The extra length of haul would roughly double the length of time required to load a barge with a given size of truck fleet, assuming product is unloaded directly onto the barge, rather than being stockpiled at the barge site.

The final alternative is a southbound haul over a gravel logging road to Queen Charlotte City. Length of haul over this route is about 55 kilometres, substantially longer than the northbound hauls, but reducing the one-way barge movement to Vancouver by about 200 kilometres. With a 55-kilometre truck haul it would likely be necessary to stockpile product at Queen Charlotte City rather than unloading directly to a barge. The resulting "double handling" would add a substantial cost burden to the operation.

2. Mica

The mica deposit is located near Squam Bay on the west side of Adams Lake. Although the site has not yet been developed, there is good road access and an underground lead/zinc mine once operated near the site. There would be 20 to 25 kilometres of haul on gravel road before reaching pavement at the community of Adams Lake.

3a. Garnet

The first of three garnet deposits is located to the west of Penticton near the Apex ski resort. There is good road access, and much of the route is paved. The site is also accessible from Hedley, on a route that would reduce the length of haul to Vancouver. However, that route apparently has steep grades and is not suitable for heavy trucks.

3b. Garnet

The second garnet deposit is located on Goldstream River, about 15 kilometres off the Mica Dam highway (Highway 23). The site would be accessed by logging roads that are capable of handling heavy truck traffic, but some limited road construction would likely be required to access the site.

3c. Garnet

The final garnet site to be considered is located on the west side of the Columbia, opposite Downey Creek. A short section of new road and a barge operation across the lake would be needed in order to access the site.

4a. Silica

There is no road access to the silica deposit at Longworth. Product could be loaded directly in railcars. Alternatively, it would be necessary to extend and upgrade existing logging roads to connect Longworth with Sinclair Mills for access to Prince George.

4b & c Silicon Carbide

Silica would be transported to Prince George, Prince Rupert or Kitimat for use in producing ferrosilicon or silicon carbide for off-shore markets.

Direct shipment to Kitimat or Prince Rupert would eliminate the cost of extra handling associated with processing at Prince George. Kitimat may have an added advantage in the form of lower cost electric power for the conversion process. Relative to Prince Rupert, it also has the benefit of an 80-kilometre saving in haul distance for truck shipments. (There is a similar mileage difference for rail shipments, but that saving is more than offset by load limits on the Terrace-Kitimat branchline and the extra switching and sorting required for Kitimat-bound railway traffic.)

5. Crushed Aggregate

The Construction Aggregates quarry near Watts Point (south of Squamish) was selected as a representative site on tide-water. There was an active operation on this site in the past but it was shut down several years ago.

The BC Rail mainline is located between the quarry and the shoreline, and it would be necessary to construct a shielded conveyor over the railway line for loading ships and barges. Ship and barge berthing facilities and shiploading facilities would also be required. As shown in Exhibit B.1, there is good water depth to accommodate ship and barge loading operations immediately adjacent to the site.

6a. Dimension Stone

Two stone quarries were selected for analysis, each with relatively good access to tidewater and to Vancouver. The first of these is already in operation, and is located near the Duffy Lake Road. Accessibility to the site has been substantially improved with upgrading of the Duffy Lake Road to highway standards.

6b. Dimension Stone

The second site is near Squamish and the Highway 99 route to Vancouver. The quarry has been active in the past and is readily accessible by road from Squamish. Distance to the Squamish Highway is about 5 kilometres.

6c. Finished Dimension Stone

The final case being considered for dimension stone is shipment of the final product. In this case, product would be shipped from a plant in Vancouver once it had been sawn, finished, and packed in crates.

7. Olivine

The olivine deposit considered in this study is accessible by highway and heavy-haul road running north from Princeton and west from Coalmont. Although the highway from Princeton to Coalmont is narrow and steep in places, it is capable of handling heavy trucks.

8. Bentonite

The Hat Creek bentonite deposit is accessible by paved and gravel road from both Cache Creek and Lillooet. Product would be trucked north from Hat Creek on high-standard gravel road, then east over the Lillooet-Cache Creek highway (Highway 12) to the TransCanada Highway.

9. Wollastonite

The wollastonite deposit is located near Fintry Point on the west shore of Okanagan Lake and is accessible by gravel road. The final section of road (about 3 kilometres in length) would require upgrading in order to handle heavy trucks.

10. Feldspar

The feldspar site is about 4 kilometres off Highway 6 to the east of Vernon and Lumby. Existing farm access roads and logging roads provide direct access to the site.

11. Nepheline Syenite

The nepheline deposit is located in high country, to the southeast of Mica Creek. There is no road access at the present time and mineral development alone would not justify new road construction. As a result, it is unlikely that this property will be developed until logging roads approach the site.

Two options are available. In the first case, the site would be accessed from the west, with about 40 kilometres of gravel road connecting to the Mica Creek Highway and to the TransCanada Highway at Revelstoke. In the second case, product would be moved to the east, tying into the TransCanada Highway east of Revelstoke after a 90-kilometre haul over gravel roads.

12. Talc

The talc site is located near Sovereign Mountain, to the east of Quesnel. The deposit is accessible by logging road.

From the foregoing description, it is evident that most sites are directly accessible by truck. In a few cases (such as the nepheline syenite deposit) there is no road access at the present time. For purposes of this analysis, it is assumed that full road access is available, with the additional cost of road maintenance and construction to be accounted for in the overall assessment of site economics. Off-highway mileage for each of the sites is low in relation to total haul distance. As a result, it would likely be less costly to load product directly into highway trucks rather than using off-highway units for the initial haul. In general, any cost savings from off-highway units would be more than offset by the extra cost of stockpiling and reloading product.

Product Characteristics

In most instances, product quality and usage are not affected by moisture, and material could be stored and transported in the open. However, the products are generally fine-grained or finely ground and would retain water if they were exposed to weather.

Any increase in moisture content would lead to increased transportation costs. (In all cases, load limits for trucks, barges and ships would be reached before space limitations become a factor and consequently the amount of product transported in one load depends on weight rather than volume. Any additional moisture reduces the weight of mineral which can be transported in a load.) In order to control moisture content (as well as avoiding segregation, product loss and contamination), the cost analysis assumes that most of the products are moved in large "poly" bags, each capable of holding 3 to 4 tonnes of product.

Handling characteristics are outlined in Exhibit 2 for each of the products. Additional information on product characteristics is included in Appendix C.

Exhibit 2

Handling Characteristics

	Specific Gravity	Bulk Density (t/m^3)	Form	Handling Method	Special Considerations
1. Perlite	2.3 - 2.8		¼" aggregate	Bulk	No protection required.
2. Mica	2.7 - 3.3	0.5 - 0.7	Finely ground	Maxi-bags	
3a. Garnet	3.5 - 4.2		Crushed and screened	Maxi-bags	
3b&c. Garnet	3.5 - 4.2		Crushed and screened	50 kg. bags	
4a. Silica	2.7	1.4 - 1.6	4" aggregate	Bulk	Equipment must be free of contaminants
4b&c. Silicon Carbide			Granular or ground	Maxi-bags	
5. Crushed Aggregate	1.4 - 1.6	Crushed and Screened	Bulk	Bulk conveyor	
6a&b. Dimension Stone	2.5 - 3.0	2.5 - 3.0	Blocks	10-20 tonne Blocks	
6c. Dimension Stone	2.5 - 3.0	2.5 - 3.0	Slabs	5-tonne crates	
7. Olivine	3.2 - 3.6	1.6	2" - 4" aggregate	Bulk	No protection required
8. Bentonite	2	0.8 - 1.0	Finely ground	50-100 kg. bags	
9. Wollastonite	2.8	0.5 - 0.8	Crushed and screened	Maxi-bags	
10. Feldspar	2.8	1.1 - 1.8	Crushed and screened	Maxi-bags	
11. Nepheline Syenite	2.7	1.4 - 1.7	Crushed and screened	Maxi-bags	
12. Talc	2.7	1.3 - 1.5	Finely ground	Maxi-bags	

Distribution Patterns

A number of representative market locations were selected for each mineral. Those locations are intended to cover potential markets and provide extensive geographic coverage for the cost analysis.

The scope of the analysis is indicated in Exhibits 3 and 4. As shown in Exhibit 3, the cases include truck, barge and deepsea vessel movements to markets in seven states, Japan, Korea and all provinces from B.C. to Quebec. In total, cost estimates are developed for about 80 routes and origin-destination pairs.

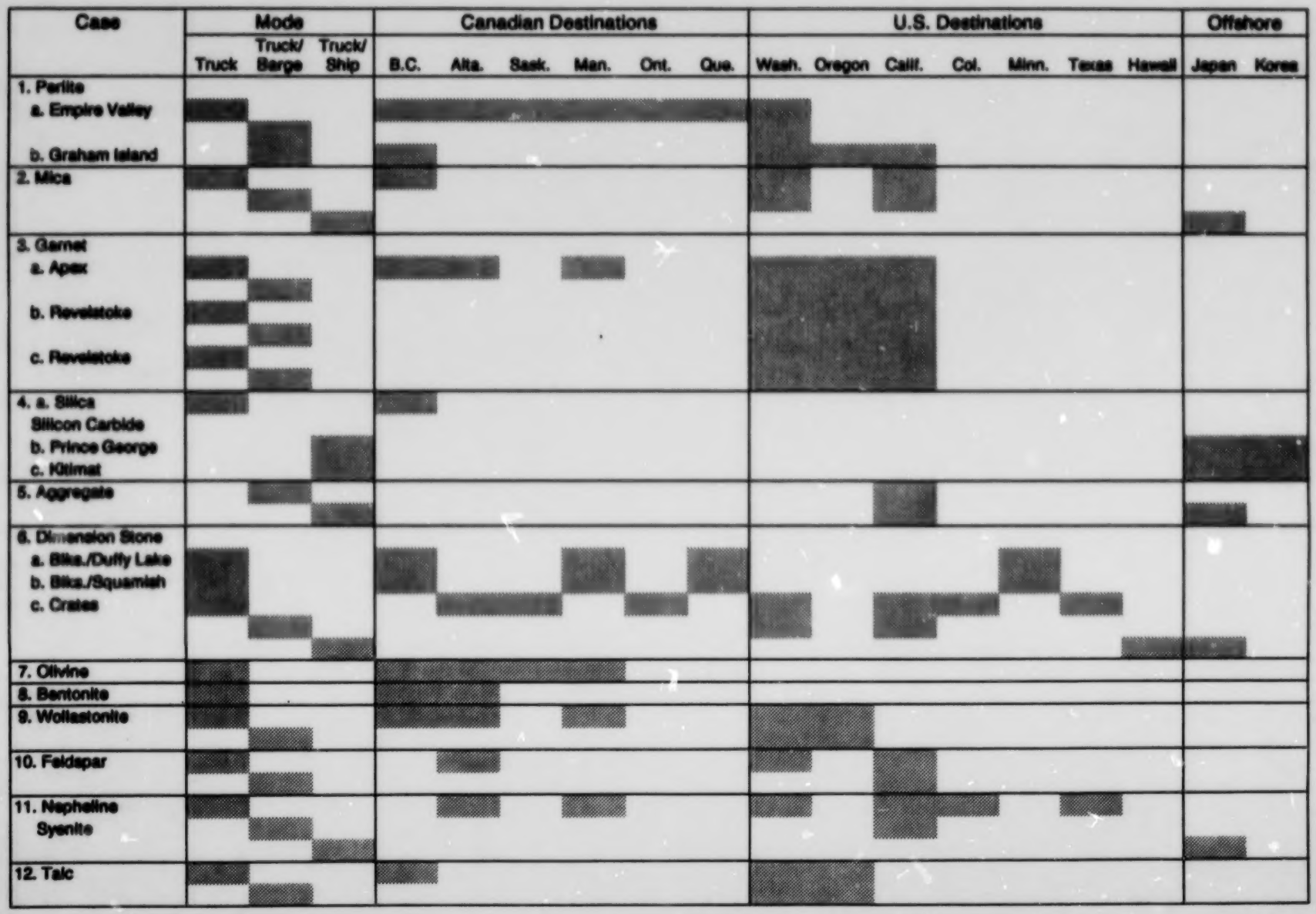
A minimum market size is required in order to sustain a viable mining operation and cases were designed to reflect realistic production levels and sales volumes. Exhibit 5 shows production levels and sales volumes assumed for the analysis. As discussed later, annual production levels and the volume of product shipped to individual destinations have a direct impact on transportation and inventory costs as well as service standards. This is particularly true for ship and barge operations.

As indicated, production ranges from 6,000 tonnes per year for placer garnet to 2 million tonnes or more for crushed aggregate. All but four of the operations would produce less than 30,000 tonnes per year, with deliveries as low as 2,000 tonnes per year for individual buyers or destinations.

Transportation cost estimates are developed for each of these movements. However, before dealing with costs for specific routes and movements, the next two sections of the report describe the methods used to estimate truck, barge and ship costs.

Exhibit 3

Overview of Modes and Markets



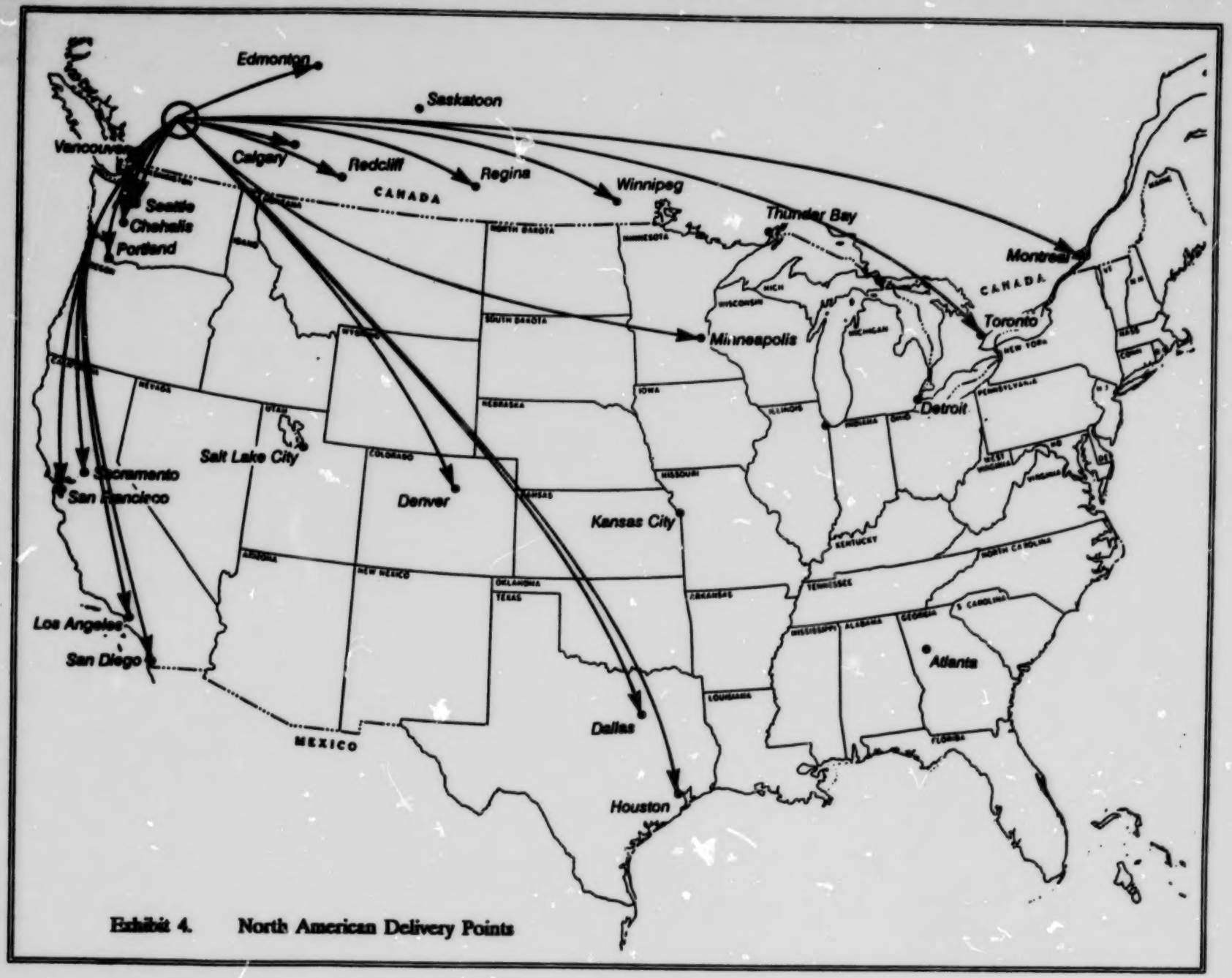


Exhibit 4. North American Delivery Points

Exhibit 5

Production Levels and Shipment Tonnages

Site	Annual Production (tonnes)	Number of Destinations	Tonnes Per Destination
1a. Perlite	25,000	7	2,000 - 6,000
b. Perlite	13,000	4	3,000 - 4,000
2. Mica	17,000	5	2,000 - 5,000
3a. Garnet	28,000	8	2,000 - 5,000
b.&c. Garnet	6,000	3	2,000 - 3,000
4a. Silica	150,000	2	150,000
b.&c. Silicon Carbide	100,000	2	50,000
5. Crushed Aggregate	2,000,000	2	1,000,000
6. Dimension Stone	20,000	4	2,000 - 12,000
7. Olivine	10,000	4	2,500
8. Bentonite	10,000	3	3,000
9. Wollastonite	10,000	5	2,000
10. Feldspar	20,000	3	7,000
11. Nepheline Syenite	100,000	9	10,000 - 20,000
12. Talc	20,000	3	7,000

3. Truck Costs

Most mineral sites in B.C. are not accessible by rail, barge or ship. This is illustrated by the fact that 14 of the 16 sites considered in this study can be accessed only by road. As a result, transportation of industrial minerals is heavily dependent on trucks, and the cost of truck transportation is an important factor in any assessment of market opportunities.

The trucking industry has become more cost-effective and competitive over the past decade, with the result that minerals, lumber, fertilizer and other bulk products are now transported by truck over much longer distances, often capturing markets that had traditionally been handled by the railways.

Much of the improvement is the result of technological advances, including improved vehicle aerodynamics, longer tire life, more efficient engines, and improved equipment durability. Fleet management systems have also led to more efficient equipment maintenance and improved driver and equipment utilization.

Changes in highway regulations have also brought about major cost reductions, particularly with increases in the allowable size and weight of trucks. Changes in this area have taken place in Canada far more rapidly than in the United States, to the point where maximum gross vehicle weight on Canadian highways is now more than 50 percent above the limit on most U.S. highways. For high-density products such as industrial minerals, the lower weight limits on U.S. highways result in per-tonne costs that are as much as 50 percent above the cost level that could be achieved with the weight limits that are in effect in Canada.

Other regulatory changes also had an effect during the 1980's, particularly the relaxation of entry controls. These changes made it easier for trucking companies to become established and expand, and led to increased competition in some sectors of the industry. However, those changes had a limited impact on costs of "truckload" operations such as those considered in this report.

Additional changes can be expected as trucking companies and equipment manufacturers attempt to reduce costs and expand the trucking industry's share of long-haul freight markets. However, relaxation of weight restrictions on the U.S. highways system has the greatest potential for cost reductions, and any change in this area would have a direct impact on the cost of reaching U.S. markets from British Columbia.

Cost estimates developed in this report reflect current equipment standards and competitive factors as well as the cost of labour, fuel, insurance and other inputs. The remainder of this section describes the cost-estimating process and the equipment that was selected for costing purposes.

Equipment

Cost estimates are developed for the largest tractor-trailer combination which can operate legally on each of the routes under consideration. As a general rule, this produces the lowest cost per tonne and the best benchmark from which to anticipate rates. However, as discussed later in this section, the type of equipment that is used for a particular movement depends on equipment availability and the extent to which backhaul traffic is available for a particular type of equipment.

The maximum load that can be transported by truck is generally determined by truck weight regulations and the empty (or tare) weight of the vehicle. Three cases are most relevant to this study: loads of 40 tonnes or more on Canadian highways; loads of about 30 tonnes on highways in the northwest states, provided that trucking companies pay special license fees for authority to carry heavy loads; and loads of about 20 tonnes on most of the U.S. highway system. Background on each of these cases is outlined below.

- 40-tonne Load: Canadian regulations allow gross vehicle weights up to 62,500 kilograms for 8-axle combination units. Depending on the tare weight of the vehicle, this allows "payloads" in excess of 40 tonnes.

It is assumed that bagged product is handled on pallets in order to minimize damage to the bags and the product. In the case of maxi-bags, each pallet would hold a single bag containing 3 to 4 tonnes of material.

Cost estimates are developed for 8-axle "B-train" units—a highway tractor hauling two trailers. Flat-deck trailers are used for the bagged product since they can be loaded faster than an enclosed van and require less loading equipment than vans. Loads would be covered with tarpaulins to provide additional protection from moisture and damage. Loading time amounts to about 1 hour, including about 20 minutes to load the product, together with an allowance for waiting time and time to cover and secure the load. Similarly, about 1 hour is provided for unloading time.

Allowing for the tare weight of a highway tractor and trailers, the maximum load which can be transported on this type of unit is about 45 tonnes.

Bulk product would be transported in hopper trailers or open-top units. Those units are heavier than flat-deck trailers and consequently must carry a lighter load in order to stay within weight restrictions. Allowing for higher truck weights, the maximum load for bulk product would be about 40 tonnes.

Loading and unloading time would depend on design of the trailer unit and the flow characteristics of the product. For this analysis, loading and unloading time is assumed to be 3/4 of an hour.

- 30-tonne Load: The Northwest States, including Washington and Oregon, allow truck weights of up to 48,000 kilograms on payment of special license fees.

  Cost estimates for hauls to Seattle, Portland and other Pacific Northwest destinations are developed for equipment operating with heavy-load permits. Vehicle configuration is the same as the previous case, with a highway tractor hauling two trailer/semi-trailer units.

  Allowing for the tare weight of the vehicle, a payload of about 30 tonnes can be handled on flat-deck trucks operating into this area. Payload is reduced to about 25.5 tonnes for bulk product.

- 20-tonne Load: For most areas of the United States, the maximum gross vehicle weight on the Inter-state Highway system is 80,000 pounds (36.3 tonnes), leading to a much lower payload and higher cost per tonne.

This limit is used in developing cost estimates for hauls to markets in California, Colorado, Minnesota and Texas, all of which involve bagged product transported on flat-deck trailers. Allowing for the empty weight of a semi-trailer unit, the maximum payload would be about 21.5 tonnes.

Tandem-axle dump trucks were used in two cases where special conditions apply. The first of these is the southernmost route to the Empire Valley perlite deposit. This is the most direct route from the minesite, but the maximum load that can be transported over the route is limited by weight restrictions on a suspension bridge that crosses the Fraser River. In order to meet these restrictions, it would be necessary to transport product in relatively small loads to a stockpile on the east side of the Fraser. Product could then be reloaded on 8-axle highway units for delivery to points in Canada and the U.S.

The second case is the haul from the perlite deposit on Graham Island in the Queen Charlotte Islands. In this case a number of factors make it likely that dump trucks would be used for the haul. Barges would probably be loaded by backing trucks up portable ramps in order to avoid the extra cost of a separate barge-loading operation. This is a relatively fast and easy operation with a conventional dump truck, but would be slower and more difficult with a larger unit. The relatively small annual volume and limited equipment availability on the Islands also make it likely that a standard tandem-axle unit would be used.

Operating Costs

Cost estimates were developed for each route, accounting for equipment type, route length, payload and other factors. Allowances were made for the extra cost of operating over gravel road into each site, and fuel costs and license fees reflect costs in each jurisdiction covered by a particular route.

Truck costs are generally broken into two broad categories: variable operating costs that depend on the time, mileage and handling methods for a particular operation; and fixed costs

that are recovered over the course of a year or the useful life of a vehicle. The following cost items are accounted for in the analysis.

Variable Costs

- Vehicle maintenance - including general servicing, periodic overhauls and major repairs to tractors and trailers.
- Drivers - including driver wages and associated fringe benefits or, in the case of owner-operators, net compensation after covering other fixed and variable costs.
- Tire costs - accounting for typical service lives for tires on tractors and trailers.
- Fuel - accounting for representative fuel consumption rates for particular vehicle configurations and loads, together with the unit cost of diesel fuel (including taxes and bulk purchase discounts) in each jurisdiction covered on a particular route.
- Loading, unloading and waiting time - reflecting the cost of unproductive driver time during loading and unloading operations as well as waiting time at border crossings, etc.
- Other costs - including miscellaneous costs associated with a particular route or operation.

Fixed Costs

- Capital charges - including capital costs, taxes and financing costs for equipment and facilities.
- Insurance, registration fees and licenses - including vehicle registration fees, licenses, permits and insurance for tractors and trailers.
- Overhead - covering expenses related to general administrative functions.

The costing procedure combines unit costs (e.g. the price of fuel, tires, and vehicles) with information on the particular route (e.g. distance, loading and unloading time, delay time, maximum legal load and average operating speed) and truck configuration (e.g. type of tractor

and trailer, tare weight, expected service life and fuel consumption) in order to arrive at an overall estimate of cost. All costs are expressed in Canadian dollars, with an 18-percent exchange rate used to convert U.S. costs into Canadian dollars.

Driver costs were estimated on the assumption that trucks are driven by owner-operators, reflecting the heavy use of owner-operators for long-haul truck-load operations. Fuel costs were determined on the basis of consumption rates that are representative of current vehicle and engine technology for the particular vehicle combinations and loads selected for the analysis. The fuel cost estimates take account of mileage covered in each jurisdiction on a particular route. For example, fuel costs on shipments to Saskatchewan were based on fuel costs of 46.9 cents per litre for fuel consumed in British Columbia, 43.5 cents per litre in Alberta, and 47.6 cents per litre in Saskatchewan.

Capital cost estimates are based on current equipment prices, representative service lives for tractors and trailers, and current interest rates. In most cases, tractor costs were taken as $100,000, with an expected service life of five years. Trailer costs vary with type and size of unit. However, 8.2-metre (27-foot) trailers were used in most cases, with an initial cost of $22,000 and an average service life of eight years.

Equipment costs and other fixed costs are allocated to individual trips on the basis of trip length and annual mileage. For example, the average annual mileage for highway tractors is taken as 200,000 kilometres, representing a high level of utilization that would generally be achieved only on long hauls. This level of use is equivalent to 10 hours of driving time each day at an average speed of 80 kph for 250 operating days each year.

Annual utilization would be far lower for tandem-axle dump trucks used for short hauls from the Graham Island and Empire Valley perlite deposits. This would be particularly true for the Graham Island operation where several trucks would be contracted on a short-term basis during barge-loading operations, with as few as four barge loads handled each year. In this case, costs are based on 48,000 kilometres per year, equivalent to about 300 kilometres per day

on relatively short hauls, 6 days per week over a 6-month season, assuming the equipment is used mainly for construction projects.

Backhaul Rates

Cost estimates for each route reflect the full cost of the return movement, assuming the truck makes the return trip without a load. These costs would provide the basis for rates in circumstances where specialized equipment or an imbalance in traffic flows makes it unlikely that a truck would be loaded in both directions. For example, shipments of silicon carbide from Prince George to Kitimat are not likely to be balanced with a return load since truck hauls in this corridor are mainly westbound hauls of lumber, mineral concentrates and other traffic destined for Prince Rupert. As a result, Prince George-Kitimat shipments would probably be forced to bear the cost of the empty return movement from Kitimat.

In many cases, truck operators will be able to match mineral shipments with return loads. Where this is the case, the total cost of the two-way movement will be split between the two loads, with the competitive position of each product as an important factor in establishing the rate. In extreme cases, truck operators would be prepared to carry loads at backhaul rates that cover only the cost of fuel or a small portion of overall costs. Peat moss, for example, is hauled to U.S. west coast markets at rates that cover only a fraction of cost. Depending on circumstances, this additional revenue can be used to set "front haul" rates below the full two-way cost, helping the operator to retain (or expand) his traffic base.

Backhaul rates would be available for many of the sites referred to in this study, particularly for deposits that are near the Lower Mainland or in the southern Okanagan. As an indication of the potential impact of two-way loads, the cost of a return movement from the Penticton area to Los Angeles is about $3,600. There is a relatively strong northbound movement into this area and good prospects for backhaul rates. Without backhaul freight, a truck operator would have to recover the full $3,600 from the northbound shipper. However, if southbound traffic were available, costs could be split between two shippers. For example, if market conditions dictated that southbound traffic would only move (or could only be captured by this

particular trucking company) if the southbound rate was set to cover only the cost of fuel and driver time, revenue from the southbound movement would amount to about $900. This would allow the operator to reduce the northbound rate while still recovering his costs. The amount of that reduction would again depend on market conditions but, for example, the northbound rate could be set to recover $2,900 while the operator retains an additional profit of $200. That is, with costs of $3,600 he recovers a total of $3,800, with $2,900 from the northbound load and $900 for the southbound load.

Even with backhaul loads, empty mileage would be involved in reaching most minesites. For example, if northbound freight were unloaded at Penticton, but the return load is to be picked up near Lumby (Site #10), total revenue from the round trip must include about $300 in additional revenue to cover loaded and empty mileage between Penticton and the minesite. Building on the previous example and assuming again that the maximum revenue from both the northbound and southbound hauls is dictated by market conditions, the trucking company would be forced to absorb the additional $300 in costs and accept a total of $3,500 in revenue for the trip, with a $100 shortfall against the full cost of the return trip.

Availability of backhaul loads is also determined by equipment types. In most trucking corridors, for example, there would be greater likelihood of gaining a backhaul movement for flat-deck trailers than for bottom-dump or end-dump trailers with the result that bagged product is more likely to benefit from backhaul rates than bulk product.

Similarly, although flat-deck trailers might be the preferred equipment for a particular movement, trucking patterns may be such that backhaul rates are available for enclosed vans but not for flat-deck units. In this case, the extra cost of using an enclosed van may be offset by savings in the backhaul rate. For example, the cost of semi-trailer vans operating between the Penticton area and Portland could be as much as 35 percent higher than B-train flat-deck trailers on a per-tonne basis with no backhaul. Use of vans would also involve extra loading and unloading costs, since they would require additional loading equipment and manpower together with longer waiting times for the driver. However, the backhaul rate on a van may be lower than rates for B-train flat-deck trailers for which there is no backhaul. In this case,

the savings from backhaul rates could offset the extra cost of freight handling. At the same time, by using vans, the shipper could gain greater operational flexibility and additional leverage in his negotiations for flat-deck B-train equipment.

4. Ship and Barge Costs

Ship and barge movements are an integral and essential part of the distribution system for a number of the cases that are considered in this analysis, including movements from the Queen Charlotte Islands and shipments to Hawaii, Japan and Korea. In addition, barge transportation may be a practical alternative to overland transportation for a number of markets, particularly those delivery points that are located on the U.S. west coast.

This section of the report provides an outline of the cost structure of barge and ship transportation, together with an overview of the costing process. Costs can be broken into four basic elements as shown below.

- Capital Cost
- Operating Cost
  - Crew
  - Crew subsistence (food, etc.)
  - Repairs and maintenance
  - Stores, supplies, and lubricants
  - Insurance
  - Administration
- Voyage Cost
  - Fuel
  - Port charges
  - Pilotage fees
- Taxes

Those items that are referred to as operating costs are usually constant annual costs which are independent of the actual work that is carried out by a vessel or the routes it operates on, provided it operates on a year-round basis. On the other hand, "voyage costs" depend on conditions on a specific route. Voyage costs can be determined directly for a given trip whereas a cost allocation process is needed in order to estimate the capital costs, operating costs and taxes that are attributable to a particular trip.

The basis for the cost estimating process is outlined below.

Capital Cost

The capital cost associated with a particular movement is determined in a two-step process.

An annual capital cost is first determined, based on replacement cost for the vessel, the after-tax cost of capital (interest cost), and the expected life of the vessel. These factors are combined to give an annual capital allowance which incorporates depreciation costs and interest expense and remains constant over the life of the vessel.

The annual capital allowance is then allocated to particular voyages and shipments. In general, the allocation is based on cargo space, time in transit, and time in port, with capital costs assigned to voyages in proportion with numbers of days and allocated to individual shipments on the basis of the amount of space occupied by each shipment.

Under Canadian shipping policy, shipments between Canadian ports must be handled by Canadian carriers. (Foreign carriers can move traffic between Canadian ports only when no suitable Canadian vessels are available.) In addition, import duties on vessels built outside Canada generally ensure that tugs and barges used in B.C. are built in the Province. For these reasons, the capital cost allowance for tug and barge movements between B.C. ports is computed on the basis of shipbuilding costs and interest charges in Canada.

International shipments can be handled by vessels from any country. Although this applies to tug and barge operations as well as deepsea shipping, Canada-U.S. barge shipments would undoubtedly be handled by Canadian or U.S. carriers.

International deepsea shipments would move in ships that are registered in other countries (referred to as "foreign" flag vessels) at rates that are set by international shipping markets. These vessels would be built in low-cost shipyards, often with tax concessions or government financing that lowers the cost of capital.

Operating Costs

As noted above, operating costs are generally broken into six cost categories. The basis for cost estimates in each of these areas is outlined below.

- Crew:

  Crew expenses consist of salaries, wages and benefits and are determined by a number of factors including nationality, conditions of service and crew size.

  Cost estimates are based on previous costing studies, labour agreements for tug boat crews in British Columbia, and discussion with operators.

  The cost of towboat crews during loading operations would depend on specific circumstances. For example, in a location such as Port Clements on Graham Island, the tug and crew would likely remain with the barge during loading operations. However, at the Vancouver end of the trip, the tug and crew would be re-assigned once the barge had been delivered to the terminal for unloading, and barge rental would be the only marine cost incurred during the unloading operation.

- Subsistence:

  Subsistence covers the cost of food and supplies for the crew and, like wages, varies over a wide range, depending primarily on nationality.

- Repairs and Maintenance:

  This cost category covers all costs associated with repair and upkeep of vessels to standards required by owners, the classification societies that set industry standards, and government agencies such as the Coast Guard. This includes the cost of routine and annual maintenance, unexpected repairs, and annual inspections. In the case of tug and barge operations, repairs and maintenance would be carried out in company-owned shops or local yards. On the other hand, deepsea vessel operators would have major refit and maintenance work carried out in low-cost yards, usually in Asian countries.

- Stores and Lubricants:

  This cost category covers all expenditure on consumable supplies and spare parts, deck and engine room equipment, and lubricants required for the running of a ship or tug and barge. As with other cost items, estimates are based on previous costing work as well as discussion with operators.

- Insurance:

  Insurance cost consists of three elements:

  - Hull and machinery insurance for protection against physical damage or loss.
  - Protection and indemnity insurance to cover third-party liability.
  - Insurance against loss of earnings, strikes, etc.

  The cost of insurance depends on a number of factors, including the size and cost of the vessel and past performance of the operator.

- Administration:

  The allowance for administration covers management costs for work such as crew selection, purchase of supplies, liaison with port authorities and shippers, dispatching, and scheduling and supervision of maintenance work.

Voyage Costs

Voyage costs include fuel, port charges and pilotage fees. Fuel costs are determined from consumption rates for the particular towboat or ship which is being considered, and includes fuel consumed at sea and in port. Port charges are based on actual fee schedules while pilotage fees are based on previous work and current fee schedules.

Marine Transportation Costs

The process is used to develop cost estimates for each of the marine routes considered in this study. Those estimates apply to specific equipment types and sizes and specific route conditions as outlined below.

As noted previously, the "flag of registry" has a direct bearing on the cost of capital and other cost factors. Canadian tug and barge costs are generally lower than U.S. costs for similar equipment and consequently cost estimates for barge shipments to the U.S. reflect Canadian costs. In the case of deepsea vessels, the estimates reflect low-cost operations represented by Liberian-flag vessels.

The type of equipment used for particular shipments depends on a number of factors, including shipment size, handling methods and navigation conditions. The following vessel types were selected to represent conditions on each route.

- Barges are standard flat-deck barges with capacity for 3,000, 4,000 or 5,000 tonnes of cargo. In each case, barges are selected to provide the closest possible fit with volume shipped to each destination.
- Barges are towed by 1,400 horsepower tugs where the route is confined to relatively protected waters on the B.C. coast. Larger 1,800 horsepower tugs are used for tows to destinations on the U.S. coast. Average sailing speed is taken as 18.5 kilometres per hour.
- Aggregate is transported in 60,000 dwt[1] vessels under Liberian registry. Average sailing speed is taken as about 30 kilometres per hour.
- Container shipments from Vancouver are handled in containerships with capacity for 1,800 twenty-foot containers, operating under the Liberian flag and sailing at an average of about 40 kilometres per hour.
- Palletized cargo is shipped in 16,000 dwt multi-purpose vessels with an average sailing speed of 33 kilometres per hour.

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1 Dwt or deadweight tonnage is a standard measure of vessel capacity and represents the number of tons of 2,240 pounds that a vessel can transport, including fuel and cargo.

Backhaul opportunities for barge shipments are extremely limited, particularly for shipments to U.S. destinations. As a result, costs are based on a one-way tow, with mineral shipments carrying the full cost of the return voyage. The following assumptions are made for deepsea shipments:

- The return movement does not affect shipping costs for containers and crates shipped through Vancouver. For example, dimension stone is shipped from Vancouver as part of a full vessel load, with Hawaii as a port of call en route to a Pacific Rim destination. Only the cost of the Vancouver-Hawaii voyage is considered in arriving at cost estimates for dimension stone.

- Shipment of silicon carbide is part of a triangular voyage between Vancouver, Kitimat and Japan. The Vancouver-Kitimat and Kitimat-Japan voyages are charged against the silicon carbide shipment.

- Aggregate shipped to both Hawaii and Japan bears the full cost of the empty return movement. That is, bulk carriers would be dedicated to this traffic, with a total of 18 to 20 trips per year to Hawaii or Japan with the return trip in ballast.

Cost estimates for each class of equipment are shown in Exhibit 6, based on current capital and operating costs. The cost of towboats is currently about $2 million for a 1,400 hp tug and $3.5 million for a 1,800 hp vessel. Barge costs range from $2.2 million for a 3,000 tonne barge to about $4 million for 5,000 tonnes. In each case, capital costs are converted to an annual cost, taking account of financing costs in the industry and allowing a 20-year service life.

Crew and repair costs are the most important components of operating costs. The crew complement for tugs is 6 for the 1,400 hp tug and 7 for the 1,800 hp tug. On average, the cost per man-day is about $400 for a unionized crew, with about $50 per day in benefits and overtime costs separating union and non-union crews. Repair and maintenance costs vary, depending on standards adopted by the owner, but $900 per day is a representative figure for a 1,400 hp towboat. Insurance costs also vary, with $50 per day as an average figure.

Voyage costs are most sensitive to fuel consumption and fuel costs, with port charges as an important factor in some operations. Fuel expenses are estimated on the basis of average daily

fuel consumption, with fuel prices at about 35 cents per litre. Port charges are determined by tariffs levied by port authorities and vary with cargo type, length of stay, shipment size and other factors.

Exhibit 6

Daily Equipment Costs

Tugboat Costs

	1400 HP Tug	1800 HP Tug
Capital Cost	$ 675/day	$1,175/day
Operating Cost	$3,800	$4,400
Voyage Cost (excl. port charges)	$1,475	$1,875
Taxes	$ 550	$ 975

Barge Costs

	3,000 Tonne Barge	5,000 Tonne Barge
Capital Cost	$ 750/day	$1,350/day

Deepsea Vessel Costs

	60,000 DWT Bulk Carrier	16,000 DWT Multipurpose Carrier	1,800 TEU[2] Containership
Capital Cost	$9,200/day	$9,200/day	$20,100/day
Operating Cost	$4,300	$5,000	$6,500
Voyage Cost (excl. port charges)	$7,200	$5,300	$6,200
Taxes[3]	0	0	0

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2 "TEU" or "twenty-foot equivalent unit" is a standard measure of container ship capacity. In this case, the selected vessle has capacity for 1,800 twenty-foot containers.

3 These vessels fly the convenience flag of Liberia, a tax-free jurisdiction.

5. Transportation Costs for Industrial Minerals

This section of the report provides transportation cost estimates for each of the cases that were described in Chapter 2. The cost estimates do not include loading costs at the minesites (that is, they are developed on a Freight on Board (FOB) basis). They do, however, include the cost of drivers, crews and equipment that are idle during the loading operation.

In most cases, annual tonnage is relatively low and delivery points are not likely to be located on waterfront sites. In order to put barge shipments on a comparable basis with trucking, cost estimates include an allowance for barge unloading costs and truck delivery to plant sites. In most cases, costs include $4.00 per tonne for terminal expenses and $4.00 per tonne for truck delivery from barge terminals to plant sites at the final destination.

Costs for each route are set out in Tables D.1 to D.4. Information presented in those tables includes the following:

- D.1 Length of haul on gravel road and paved road.
- D.2 Truck type, payload and cost estimates.
- D.3 Ship and barge costs.
- D.4 The combined cost of truck and marine movements as well as transfer costs at intermediate points.

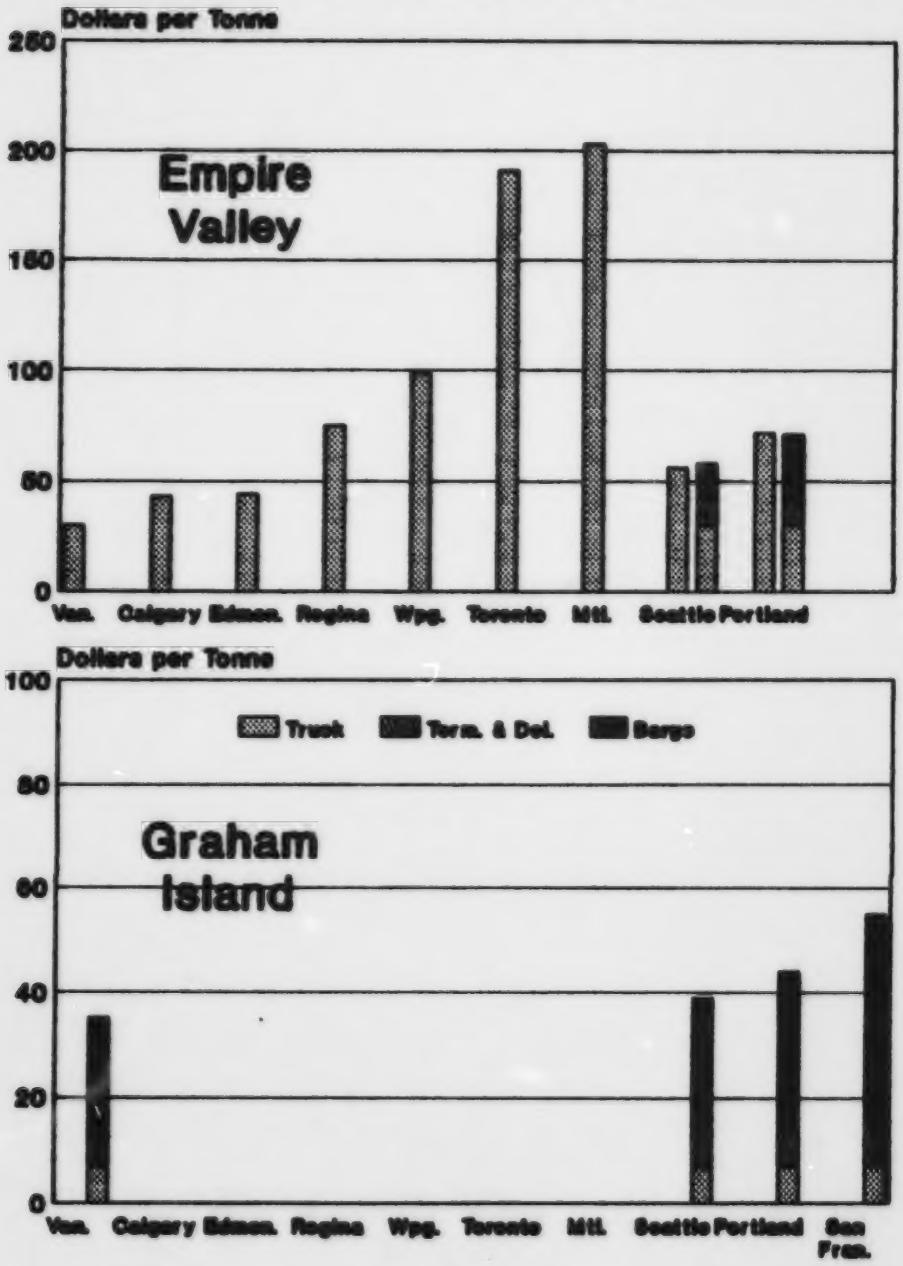
The resulting cost estimates for potential mineral developments are discussed below.

Perlite

The estimated cost of delivering perlite from the Empire Valley and Juskatla (Graham Island) sites is shown in Exhibit 7. The Empire Valley costs are based on the longer route through Williams Lake, with a full highway load transported directly from the minesite. The following points should be noted:

Exhibit 7

Perlite Transportation Costs



- Product is shipped in bulk form as a fine aggregate. Given the nature of the equipment used for this haul, it is unlikely that backhaul loads would be available for either truck or barge shipments, and consequently cost estimates are based on a one-way haul.

- The cost of barging is sensitive to terminal costs and the length of haul (if any) from the waterfront unloading site to the customer's plant. This is evident from the fact that the allowance for barge unloading and truck delivery in Vancouver represents nearly one half of the cost of shipping product from Graham Island.

- The cost of barge transportation is also sensitive to volumes being handled. For the volume of perlite being considered, shipments would be handled in barges with a capacity for 3,000 tonnes or 5,000 tonnes and the cost per tonne would increase substantially for part loads. For this analysis, shipments to Vancouver, Portland and San Francisco are handled on fully-loaded 3,000 tonne barges. On the other hand, the 4,000-tonne shipment to Seattle moves on a partially loaded 5,000-tonne barge, resulting in a significant cost penalty.

- In comparing truck and barge transportation, consideration must be given to customer requirements and overall logistics costs. With expected production and sales volumes, a single barge shipment would represent a full year's supply to each destination, with a substantial impact on inventory and storage costs.

- The availability of barge terminal space and the cost of terminal handling would also be affected by annual tonnage. In the case of the Graham Island deposit, it would be necessary to negotiate terminal arrangements for one shipment per year to the Vancouver, Seattle, Portland and San Francisco markets, dealing with terminal operators whose primary interest is in large-volume shipments rather than small, infrequent loads.

- Length of haul for Empire Valley product can be reduced by taking a more direct route to Clinton, crossing the Fraser River on a suspension bridge at the Gang Ranch. However, load restrictions on the bridge mean that product must initially be transported in small trucks, stockpiled on the east side of the River and reloaded on highway units. This additional handling entails extra costs which offset savings from the shorter haul. As shown in Exhibit D.4, total costs on the shorter route would likely be slightly higher than costs on the long route.

- The suspension bridge was built in the early 1900's and is in poor condition. Design for a replacement bridge should be completed in the fall of 1990 and a new structure will likely be completed within the next five years. The new bridge would reduce length of haul from the Empire Valley by 180 to 220 kilometres, relative to the Williams Lake routing. This represents 30 percent of the haul distance to Vancouver and would result in significant cost savings.

Mica

Cost estimates have been developed for a total of 20,000 tonnes of mica per year, moving from a site which is located north of Chase to markets in Vancouver, Japan and the Western States. The resulting estimates are summarized in Exhibit 8, assuming that no return loads are available.

Cost estimates are summarized below.

- The cost of transporting mica with no backhaul would be approximately as follows:

	All-truck	Truck/marine
Vancouver	$18 per tonne	--
Seattle	$35	$50
San Francisco	$125	$55
Los Angeles	$160	$70
Japan	--	$65

- Shipping costs to Japan assume product is moved in standard 20-foot containers. The trucking cost estimates assume no backhaul traffic is available and mica shipments cover the full cost of a two-way haul.

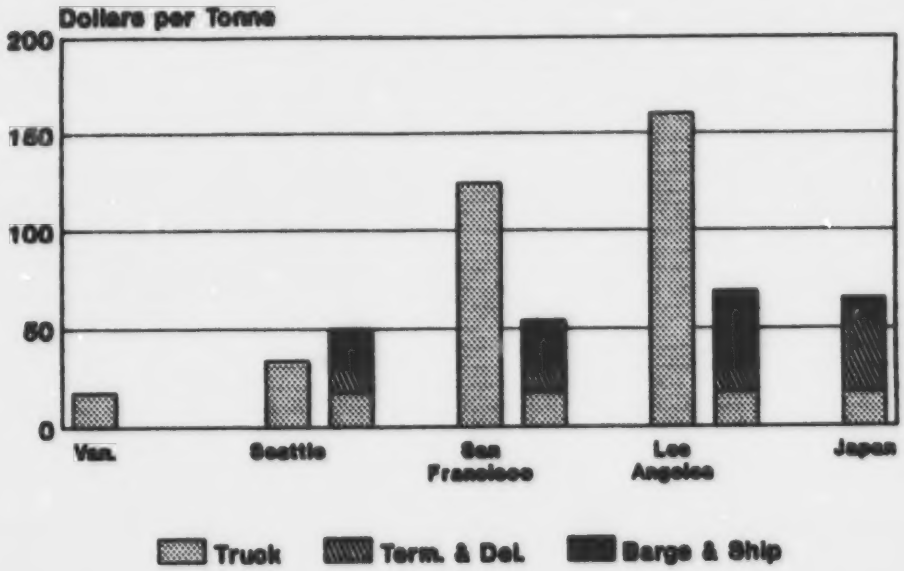
- Backhaul rates would be available for a portion of annual production. However, availability of backhaul would depend on the required standard of service. For example, the proportion of output that moves under backhaul rates would be higher if shipping schedules are flexible and do not require delivery on tight schedules with little advance notice.

- Cost estimates for barge delivery to Seattle reflect the higher cost of moving 2,000 tonnes of product on a barge that can handle 3,000 tonnes of product. However, even with a full load, costs would not be competitive with direct delivery by truck.

- Although barge costs for shipments to San Francisco and Los Angeles are lower than direct delivery by truck, the cost, risk and organizational effort associated with once-a-year deliveries by barge are likely to over-ride the cost difference. The cost and service implications of delivery once a year are substantial when they are compared with the standard of service provided by 2 to 3 truckloads per week. In addition, backhaul rates would likely be available for the truck movements but there would be little likelihood of return barge movements.

Exhibit 8

Mica from Adams Lake
North of Chase



- Delivery costs to U.S. destinations could be reduced by a substantial amount in the future if loading restrictions on U.S. highways are increased to approach the levels which are now in effect in Canada. For the markets considered here, the greatest effect would be on California rates. However, rates to Washington and California would also be affected.

- Delivery costs to Japan include an allowance for terminal handling costs of $350 to $400 per container.

- As discussed earlier, container shipping costs are based on ship operating costs which are allocated to traffic on the basis of space occupied on the ship. The actual rate for a particular shipment would depend on negotiations with shipping lines and factors such as the value of the commodity, annual tonnage, and conditions in international shipping markets.

Garnet

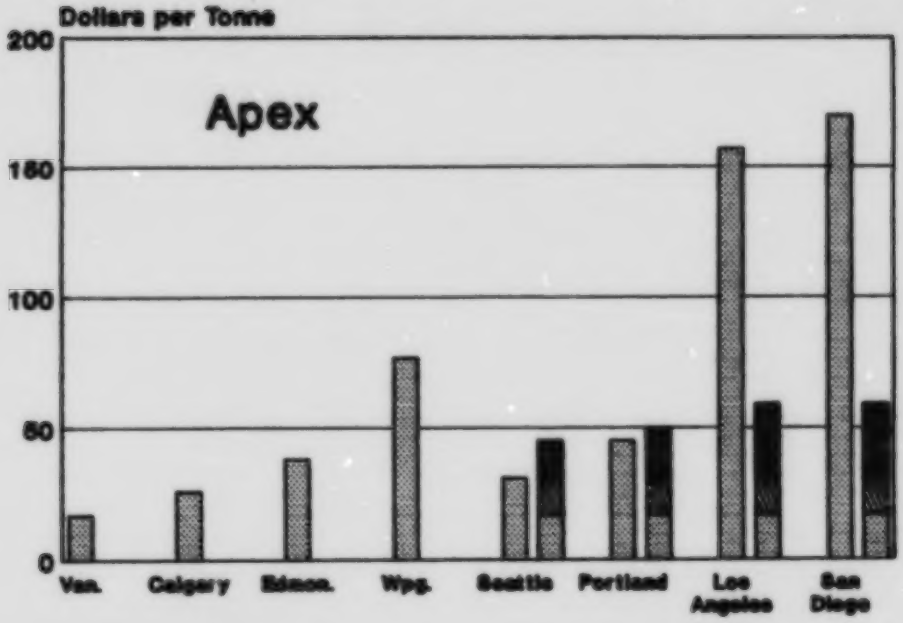
Cost estimates for garnet are summarized in Exhibit 9 and discussed below.

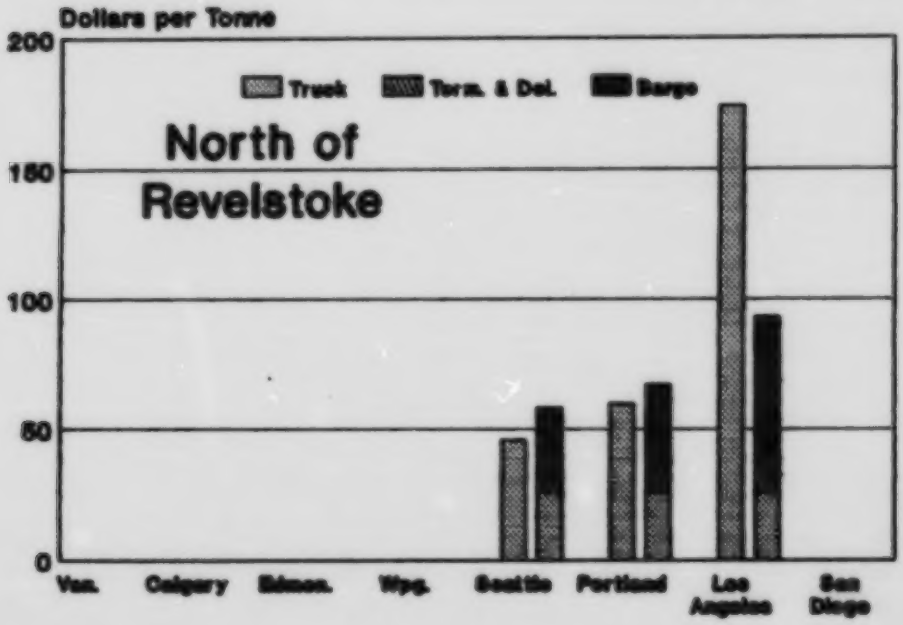
- Cost estimates were developed for three garnet deposits—a site at Apex Mountain, to the west of Penticton and two sites to the north of Revelstoke. Exhibit 9 refers to the most northerly of the Revelstoke deposits, with costs from the southerly site being about $1 per tonne lower. Both of the Revelstoke sites would require construction of short sections of road, and the cost of road construction and maintenance is not included in the estimate. Similarly, the southernmost Revelstoke site would require a barge or scow operation across Revelstoke Lake. The cost of establishing and operating that system is not included in the estimates.

- Cost estimates are summarized below, with trucking costs based on a two-way movement and no return load.

Exhibit 9

Garnet





	All-truck	Truck/marine
From Apex Mountain Site		
Vancouver	$17 per tonne	--
Calgary	$25	--
Edmonton	$40	--
Winnipeg	$75	--
Seattle	$30	$45 per tonne
Portland	$45	$50
Los Angeles	$155	$60
San Diego	$170	$60
From North of Revelstoke		
Seattle	$45 per tonne	$60 per tonne
Portland	$60	$65
Los Angeles	$175	$95

- Conditions are similar to those for mica. There are good prospects for truck rates based on a two-way haul, depending on flexibility in shipping schedules, and costs of barge delivery will be heavily dependent on terminal costs and the cost and logistics burden of making a single delivery each year.

- The Apex and Revelstoke products have different characteristics and would be directed to different markets. The resulting difference in annual tonnage has a significant impact on barge costs. In the case of Apex product moving to Seattle and Portland, cost estimates reflect the fact that 4,000 tonnes of product would be moved on barges with 5,000-tonne capacity. However, even with fully-loaded 5,000-tonne barges, costs would be higher than trucking. Similarly, all of the per tonne estimates for Revelstoke product are for 2,000-tonne shipments on 3,000-tonne barges. If the market allowed, an additional 1,000 tonnes could be moved on each barge at little additional cost.

Silica and Silicon Carbide

The silica deposit at Longworth is not accessible by road at the present time, and extension and upgrading of logging roads would be required if product were to be transported by truck.

Silica could be converted to ferrosilicon or silicon carbide for export to offshore markets, with Kitimat and Prince George as potential processing locations. In the case of silicon carbide, product would be bagged and require no special handling. However, ferrosilicon is sensitive to moisture and special handling methods would be required to ensure that product was not damaged in transit by absorption of moisture. Moisture protection could be provided by transporting product in lined containers. However, this would lead to very high handling costs, in part because of availability of containers and in part because of space requirements for containers.

At the present time, there is no container traffic moving through the Ports of Kitimat or Prince Rupert. As a result, empty containers are not available for overseas shipments and ferrosilicon would bear the full cost of transporting empty containers to Kitimat or Prince George.

With ferrosilicon, the product would fill only a fraction of the space in a container once it was filled to its maximum weight capacity. However, ocean freight would be based on the amount of space occupied by the container rather than the weight of product and consequently freight costs per tonne would be high. For these reasons, cost estimates are based on an assumption that silica is converted to silicon carbide which is shipped in maxi-bags on pallets or, alternatively, that ferrosilicon is moved in the same manner, but with each pallet plastic-wrapped for additional protection from moisture.

Cost estimates are summarized below.

- Silica could be transported from Longworth to Prince George at an estimated cost of $7 per tonne in bottom-dump or end-dump trucks. Shipping costs to a plant in Kitimat would be about $30 per tonne. Given the fact that this is a bulk product and most traffic in this corridor is moving in the westbound direction, there would be no backhaul. With 150,000 tonnes moving each year, about 12 truckloads would be moved every day, six days a week.

- This study has not dealt with railway costs. However, with this volume of traffic, rates to Kitimat could be in the order of $25 per tonne, providing a substantial saving over trucking costs. Factors that would

affect rate negotiations with the railways would include: competitive pressure from truckers; whether or not transportation costs are a critical factor in establishing the new plant; the type of railcar equipment that is required; and the division of responsibility for car ownership, liability, etc. between the shipper and the carrier. The rate would also reflect the fact that the branch line to Kitimat is weight-restricted and cannot handle mainline loads. As a result, cars cannot be filled to capacity and costs per tonne are higher than they would be for delivery to a mainline point. Rates will also incorporate additional car handling costs at Terrace as Kitimat-bound traffic is switched from the CN northline to the branchline. (Although rail distance to Kitimat is about 90 kilometres less than the distance to Prince Rupert, load limits and additional switching costs would offset Kitimat's mileage advantage.)

- Delivery costs from Kitimat to Japan or Korea would be in the order of $22 per tonne, with actual cost depending on the outcome of negotiations with shipping lines and terminal operators. With an allowance for trucking, the cost of shipping from a Prince George plant to markets in Japan and Korea would be in the order of $55 per tonne. Once again, trucking costs are based on a one-way haul since there is little likelihood of a return movement.

Crushed Aggregate

With annual volumes of 1 million tonnes or more, crushed aggregate would be moved to California or Japan in bulk carriers. No backhaul traffic would be available and consequently the vessels would be empty for the return movement.

Costs are developed for vessels with 60,000 tonne capacity, assuming that product is loaded directly from the site, without additional handling. On this basis, shipping costs to San Francisco are estimated at about $3 per tonne while costs to Japan would be about $10 per tonne.

The cost of constructing and operating a ship berth and ship loading gear at the Squamish site would represent additional costs. Similarly, ship unloading costs would be incurred at the destination.

Dimension Stone

Trucking cost estimates were developed for two quarry sites north of Vancouver—one at Duffy Lake and the other near Squamish. In addition, cost estimates were produced for delivery of finished stone from Vancouver to centres across Canada and the U.S. as well as overseas. The resulting estimates are discussed below.

- The cost of transporting blocks from the Duffy Lake site is shown in Exhibit 10 assuming no backhaul loads. Estimates assume that trucks are loaded to their full limit. However, this would not be the case in practice since it is unlikely that a load of 10- to 20-tonne blocks would be an exact match with load limits. To the extent that loads fall short of the maximum, costs per tonne would be increased accordingly.

- The estimated cost of trucking from the Duffy Lake quarry is summarized below.

Vancouver	$10 per tonne
Winnipeg	$95
Montreal	$190
Minnesota	$205
Japan	$35

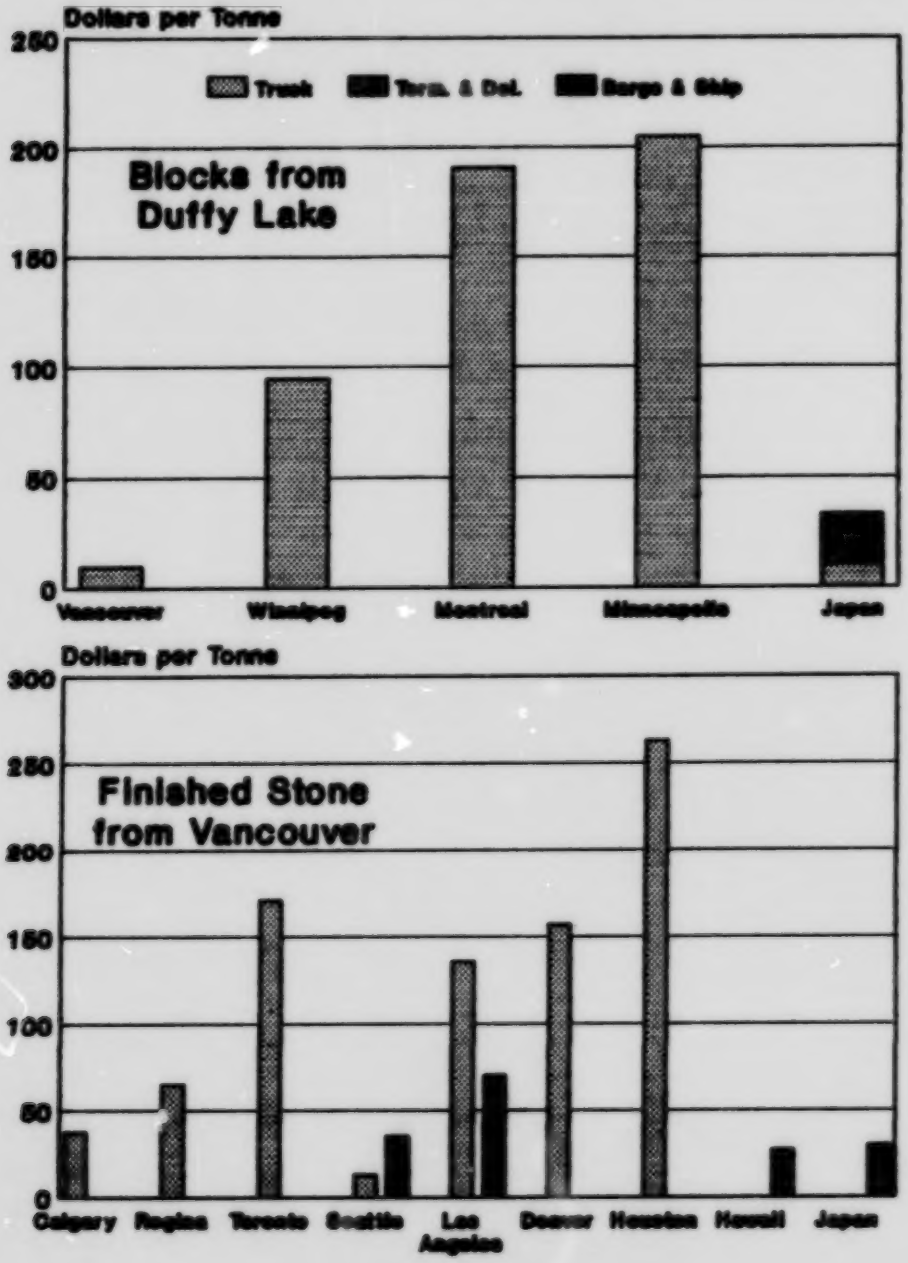
Costs from the Squamish site would be $5 to $6 per tonne lower.

- The cost of delivering finished product in crates is shown in Exhibit 10 and ranges from about $13 per tonne to Seattle to about $265 per tonne for Houston, assuming no backhaul. Those costs are summarized below.

	All-truck	Truck/marine
Vancouver	$35 per tonne	--
Regina	$65	--
Toronto	$170	--
Seattle	$13	$35 per tonne
Los Angeles	$135	$70
Denver	$155	--
Houston	$265	--
Hawaii	--	$25
Japan	--	$30

Exhibit 10

Dimension Stone



Olivine

Olivine would be moved as a bulk product from the southern Interior of the Province to Prince George or the Prairie Provinces with virtually no possibility of a backhaul movement. Total production would amount to about 10,000 tonnes per year or about 5 truckloads per week. For this analysis, loads are distributed among four destinations, covering the four western provinces. Trucking costs would be approximately as follows:

Prince George	$30 per tonne
Edmonton	$45
Regina	$65
Winnipeg	$90

Bentonite

The bentonite case assumes that about 10,000 tonnes of product is shipped from the Hat Creek area each year. Product would be bagged in 50 to 100 kilogram bags at the site, loaded on flat-deck trucks, and covered with tarpaulins.

- Trucking cost estimates for the return trip are summarized below.

Calgary	$16 per tonne
Edmonton	$25
Vancouver	$35

Wollastonite

Shipping costs for wollastonite are shown in Exhibit 11 and discussed below.

- Estimates in Exhibit 11 represent the two-way cost of a truck haul from north of Kelowna to each destination. Those estimates are summarized below.

	All-truck	Truck/marine
Vancouver	$20 per tonne	--
Calgary	$20	--
Winnipeg	$70	--
Seattle	$35	$50 per tonne
Portland	$50	$60

- The final 3 kilometres of road into the site would require upgrading in order to handle heavy trucks.

- Depending on shipping requirements, availability of backhaul rates from this site would be relatively good, given its location in the southern Okanagan.

- Location of this deposit gives trucking a clear advantage over barge shipments for destinations in the Pacific Northwest.

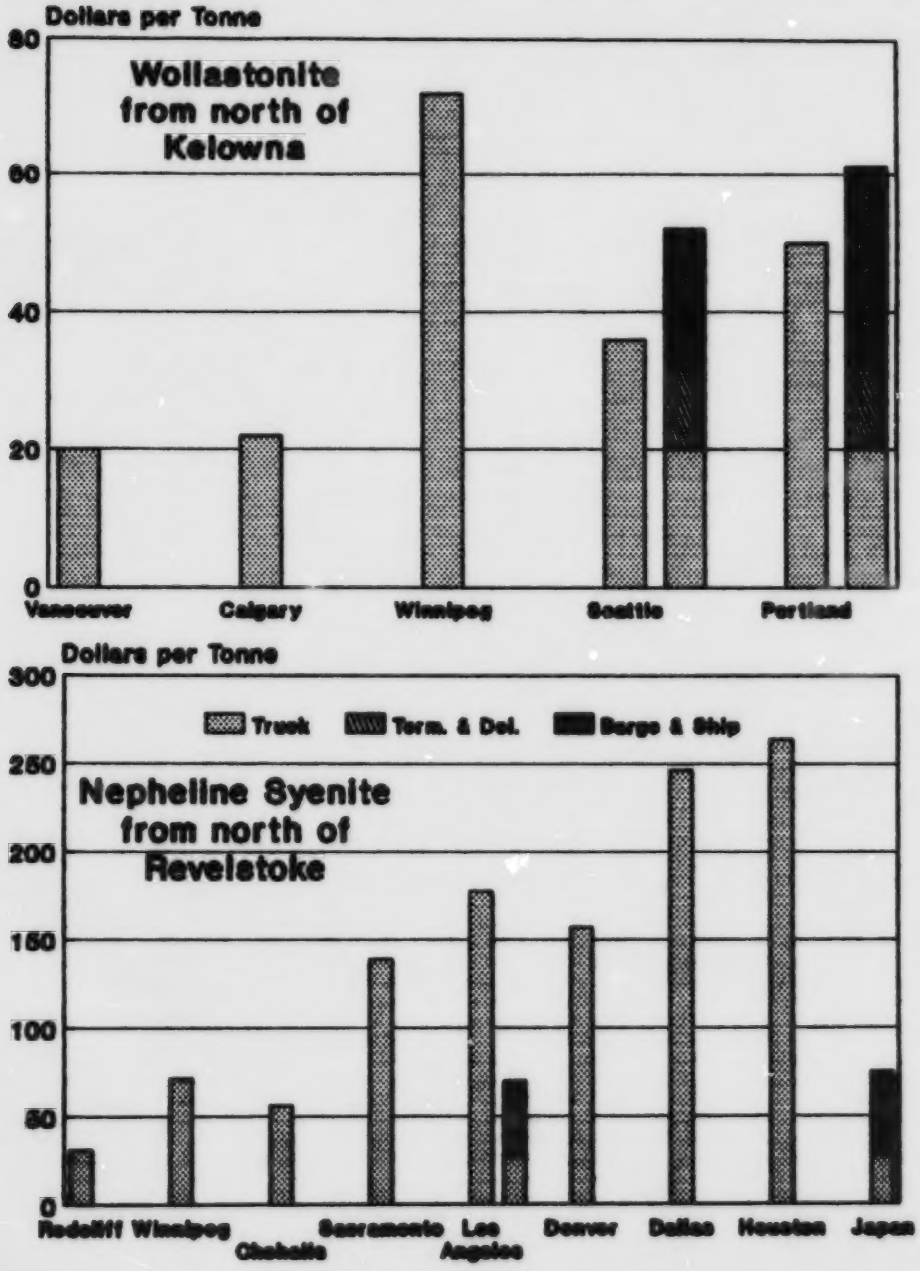
Feldspar

Feldspar would be shipped in maxi-bags from the Lumby site for glass-making operations in Alberta (Redcliff), Washington (Chehalis), and California (Sacramento). Annual production of 20,000 tonnes per year is distributed evenly between the three potential markets but differences in weight limits for trucks result in substantial differences in numbers of loads and in delivery costs. About 150 loads per year or three per week would be required to deliver 7,000 tonnes per year to Redcliff. About 230 trips would be needed to deliver the same amount to Chehalis (in trucks that are operating with overweight permits) and 330 trips per year to Sacramento. Cost estimates are summarized below.

• Redcliff	$30 per tonne
Chehalis	$120
Sacramento	$45

Exhibit 11

Wollastonite and Nepheline Syenite



Nepheline Syenite

The nepheline syenite operation would produce relatively high volumes, with a total of about 100,000 tonnes of production each year. Delivery volumes to individual buyers would also be relative large, with about 10,000 tonnes per year as a representative volume. Cost estimates are summarized in Exhibit 11 and discussed below.

- Transportation costs would be approximately as follows, assuming no return loads are available.

	All-truck	Truck/marine
Redcliff	$30 per tonne	--
Winnipeg	$70	--
Chehalis, Wash.	$55	--
Sacramento	$140	--
Los Angeles	$180	$70 per tonne
Denver	$160	--
Dallas	$250	--
Houston	$265	--
Japan	--	$75

- Location of this site would limit the availability of backhaul loads. Even if return loads were available, they would likely be destined for the Lower Mainland or the Okanagan, with an empty haul of 400 to 700 kilometres to reach the minesite.

- This site is not accessible by road at the present time and mine development is not likely to support development of an access road. Even when forest access roads have developed to the point where they approach the deposit, additional road construction will likely be required to reach the site. Costs would also be affected by location of the mill and whether it is located at the minesite or at a lower elevation, closer to the highway.

- The cost estimates shown above are based on access from the Mica Creek highway to the west of the site. Depending on development of forest access roads, the site could be accessed from the east rather than the west. This would reduce length of haul to eastern markets by about 100 kilometres with a corresponding reduction in trucking costs.

- An annual volume of 20,000 tonnes to Japan represents a significant volume of container traffic, with about 1,000 20-foot containers, each carrying 18 to 20 tonnes of product. Product would likely move to Vancouver on flat-deck trucks and be loaded in containers once it

reached the Vancouver area or the marine terminal. (The high cost of transporting empty containers to the Revelstoke area would impose a substantial additional cost, making it more economical to fill containers in Vancouver.)

- Rail transportation would be a competitive option for some of the potential markets identified for nepheline syenite. Deregulation and increased weight limits for trucks have extended the competitive reach of truckers. However, with volumes of up to 20,000 tonnes per year for the California and Texas markets, tonnage is in a range in which rail transportation would be competitive. Like most of the cases addressed in this study, the nepheline syenite deposit is not on a rail line. Product would initially be transported by truck for transfer to rail at Revelstoke and overall delivery costs would include the cost of truck transportation, transferring the product from truck to rail, and possibly storing product in Revelstoke on a short-term basis. Rail costs would depend on the number of cars that are shipped at a time, the type of equipment and the number of tonnes per car, whether product is shipped in bulk or bagged form, and sensitivity of the market to transportation costs.

Talc

The cost of shipping talc from Quesnel to selected markets is outlined below, assuming no backhaul loads are available.

	All-truck	Truck/marine
Vancouver	$30 per tonne	--
Seattle	$50	$55 per tonne
Portland	$65	$60

- Barge costs to Seattle and Portland are estimated on the basis of fully-loaded 5,000-tonne barges. However, market potential was estimated at 7,000 tonnes per year and costs would be somewhat higher because of the need to ship, for example, a 3,000-tonne load on a 3,000-tonne barge and a 4,000-tonne load on a 5,000-tonne barge in order to meet a 7,000-tonne commitment.

6. Conclusions

The purpose of this report is to provide cost estimates for a series of specific minesites and markets, with costs developed to a level of detail that is useful for "pre-feasibility" assessment of development potential. Those estimates were presented in Section 5 of the report. However, the analysis also leads to a number of general observations on transportation costs for industrial minerals produced in B.C.

- Most of the sites selected to represent industrial mineral deposits in B.C. are accessible only by road.

- Most markets for industrial minerals are relatively small, typically with potential for 3,000 to 5,000 tonnes of product each year. Small market size also favours truck transportation.

- Barge transportation has limited potential for delivery of industrial minerals. In most cases, barging from Vancouver appears to be less costly than trucking to California. However, with anticipated volumes, the barge option would involve a single shipment of 3,000 to 5,000 tonnes each year. Apparent cost savings would be offset by inventory costs and logistics problems associated with a once-a-year operation.

- In most of the cases considered in this study, truck transportation is more expensive for product that is transported in bulk form rather than in bags. The extra cost results from the fact that backhaul opportunities are reduced and tare weights of trucks are generally heavier, reducing the "payload" that can be handled on each trip.

- There are good opportunities for backhaul rates for shipments out of the southern area of the Province on flat-deck trucks or in vans. However, availability of backhaul rates is heavily dependent on the standard of service that is required. For example, a shipper who is able to give truckers a degree of flexibility is likely to have lower transportation costs than a shipper who requires transportation services on short notice and a tight delivery schedule.

- Trucking costs to U.S. markets are affected by highway load restrictions which are far more severe than in Canada. The effect of those restrictions has been eased to a certain extent in the Pacific Northwest by a licensing system that allows truckers to handle larger loads in return for payment of special fees. However, maximum vehicle weight in California and most other states is about 60 percent of limits in Canada.

That difference reduces the payload that can be handled on a single shipment to California to less than half of that for a Canadian shipment.

- Although there is strong opposition to more liberal regulation of truck weights on the U.S. highway system, weight limits will likely be increased in future. Any substantial change will reduce the cost of trucking to U.S. markets.

- Although this study has not dealt with railway costs, rail transportation may be an alternative means of serving markets that are most distant from B.C. However, most of the sites considered in this study would be accessible only by road, and transportation by truck from minesite to a railway siding would be an important cost element, even where product is shipped by rail.

- Railway costs are sensitive to a number of factors including the type of equipment that is required, the number of cars that are shipped at one time, the cost of shipping via alternative routes or modes, and the total volume to be shipped each year. For example, the cost of shipping 3,000 tonnes of product to a single California destination with one carload of product shipped every week would be considerably higher than cost for a total of 20,000 tonnes per year to two destinations in California with shipments moving in 10-car blocks.

- Large volumes of bulk product can be delivered by ship at costs in the range of $3 per tonne (to California) to $10 per tonne (to Japan).

- In cases where a small volume of palletized or containerized product is being moved, costs are increased substantially by terminal and handling costs. For example, container handling rates are generally in excess of $300 per twenty-foot container. Those rates are small in relation to the value of manufactured products which are commonly shipped in containers. However, when terminal costs at both ends of a voyage are applied to a 20-tonne load of industrial minerals, they represent a cost burden of more than $30 per tonne and exceed the cost of the voyage itself.

Appendix A

Site Locations

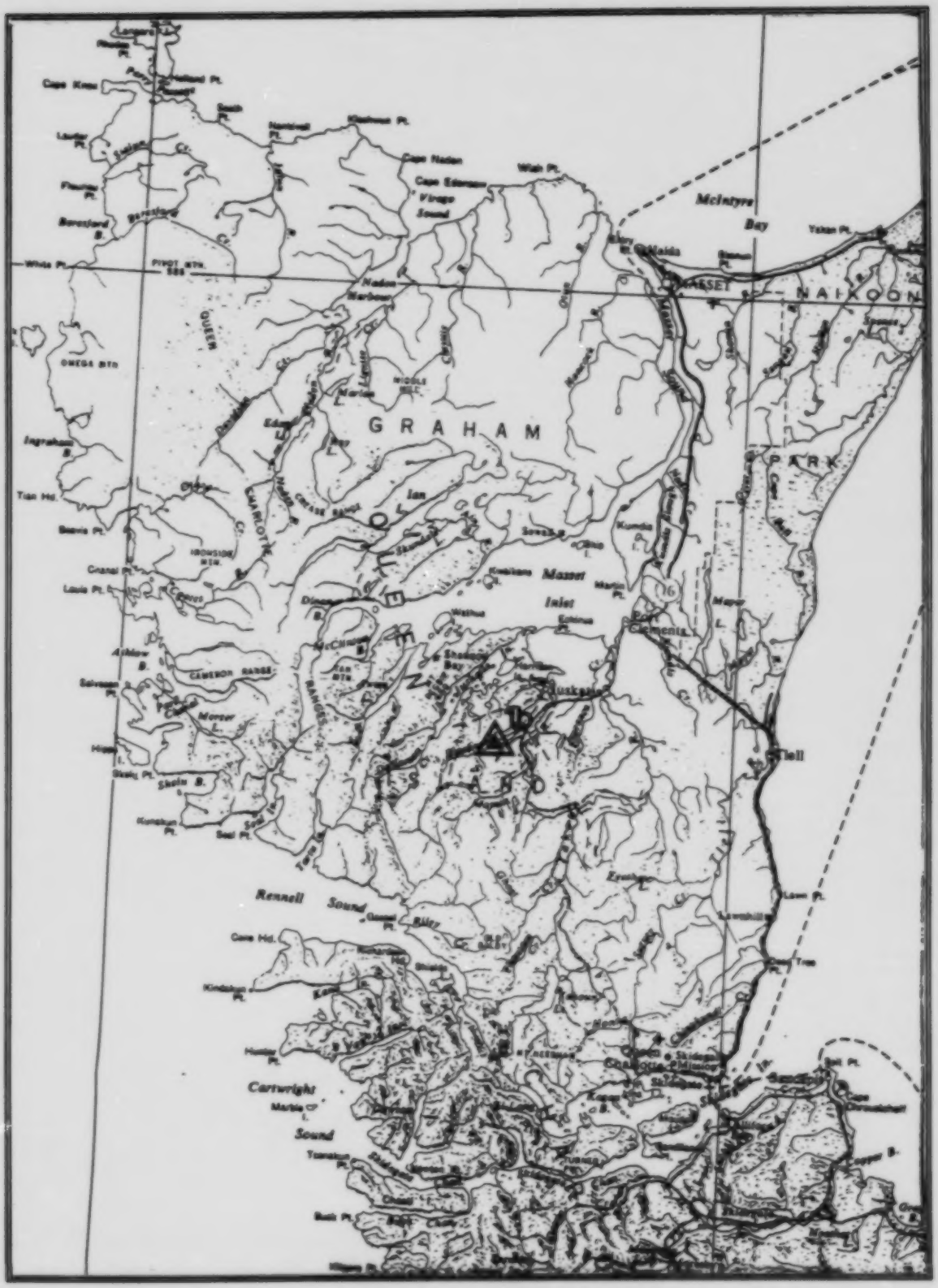


Exhibit A.1 Perlite Site

Exhibit A.2 Crushed Aggregate and Dimension Stone Sites

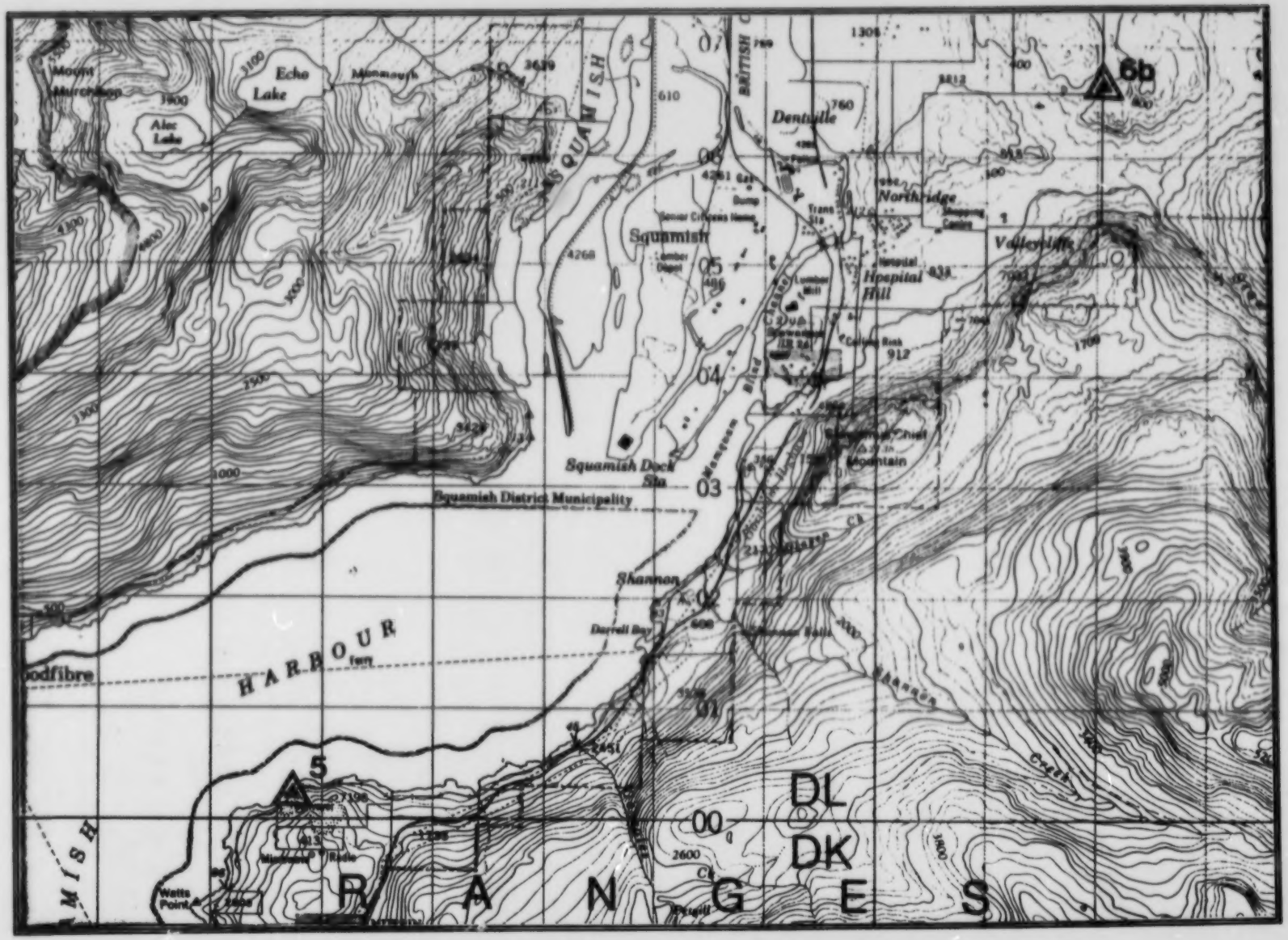


Exhibit A3 Crushed Aggregate and Dimension Stone Sites

Exhibit A.4 Perlite, Bentonite and Dimension Stone Sites

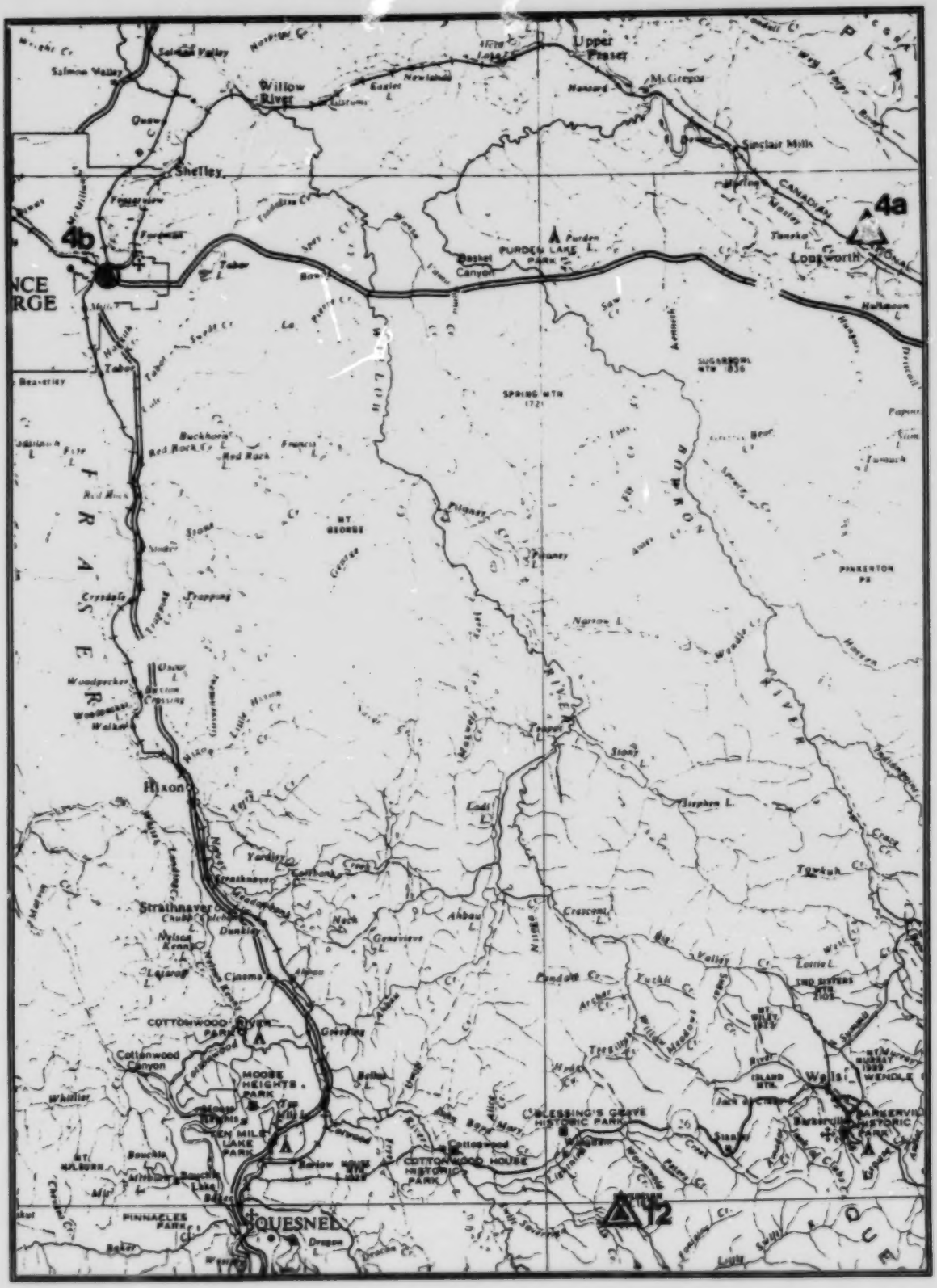


Exhibit A.5 Talc and Silica/Silicon Carbide Sites

Exhibit A6 Olivine Site

Exhibit A.7 Wollastonite and Garnet Sites

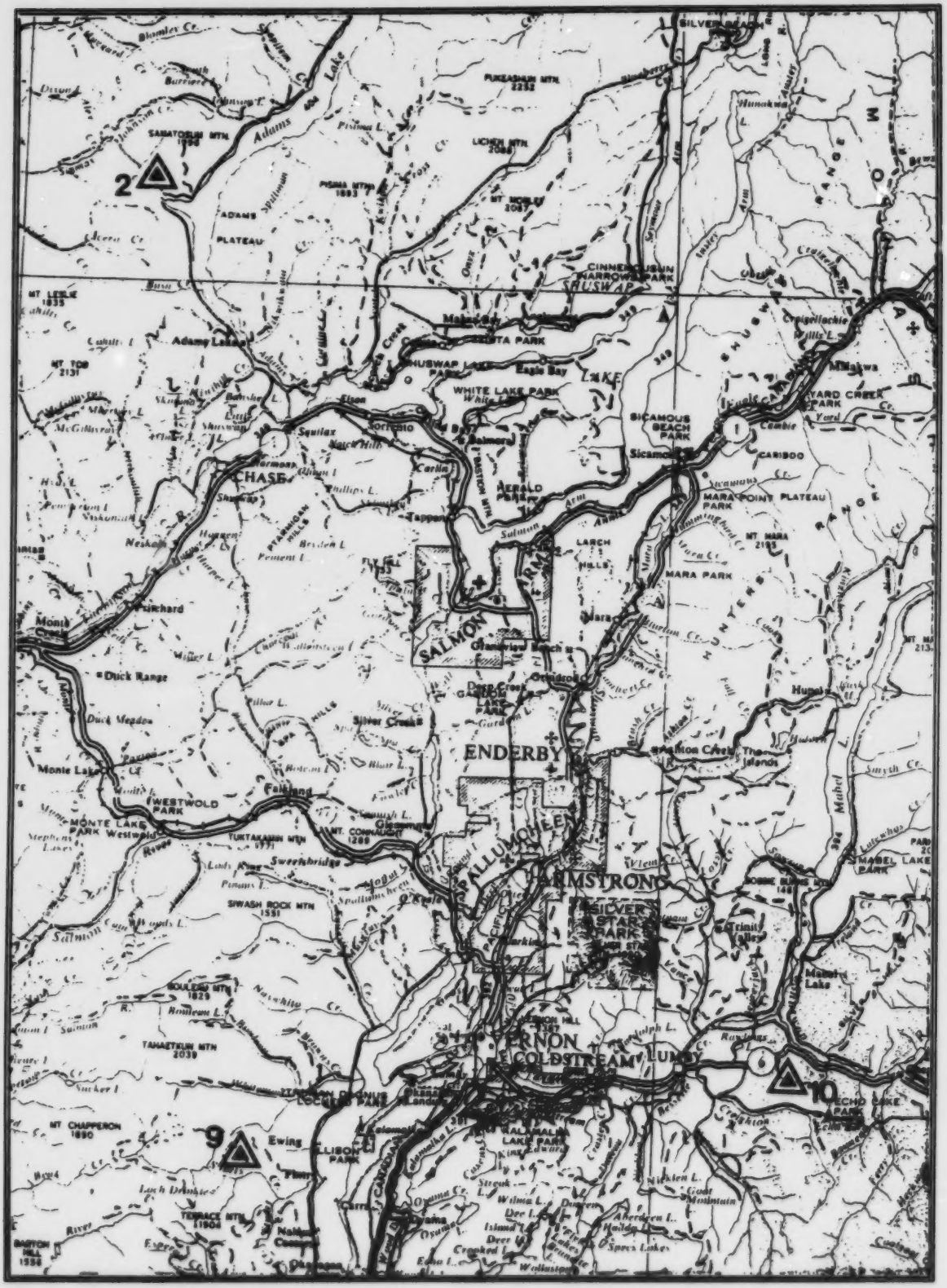


Exhibit A.8 Mica, Feldspar and Wollastonite Sites

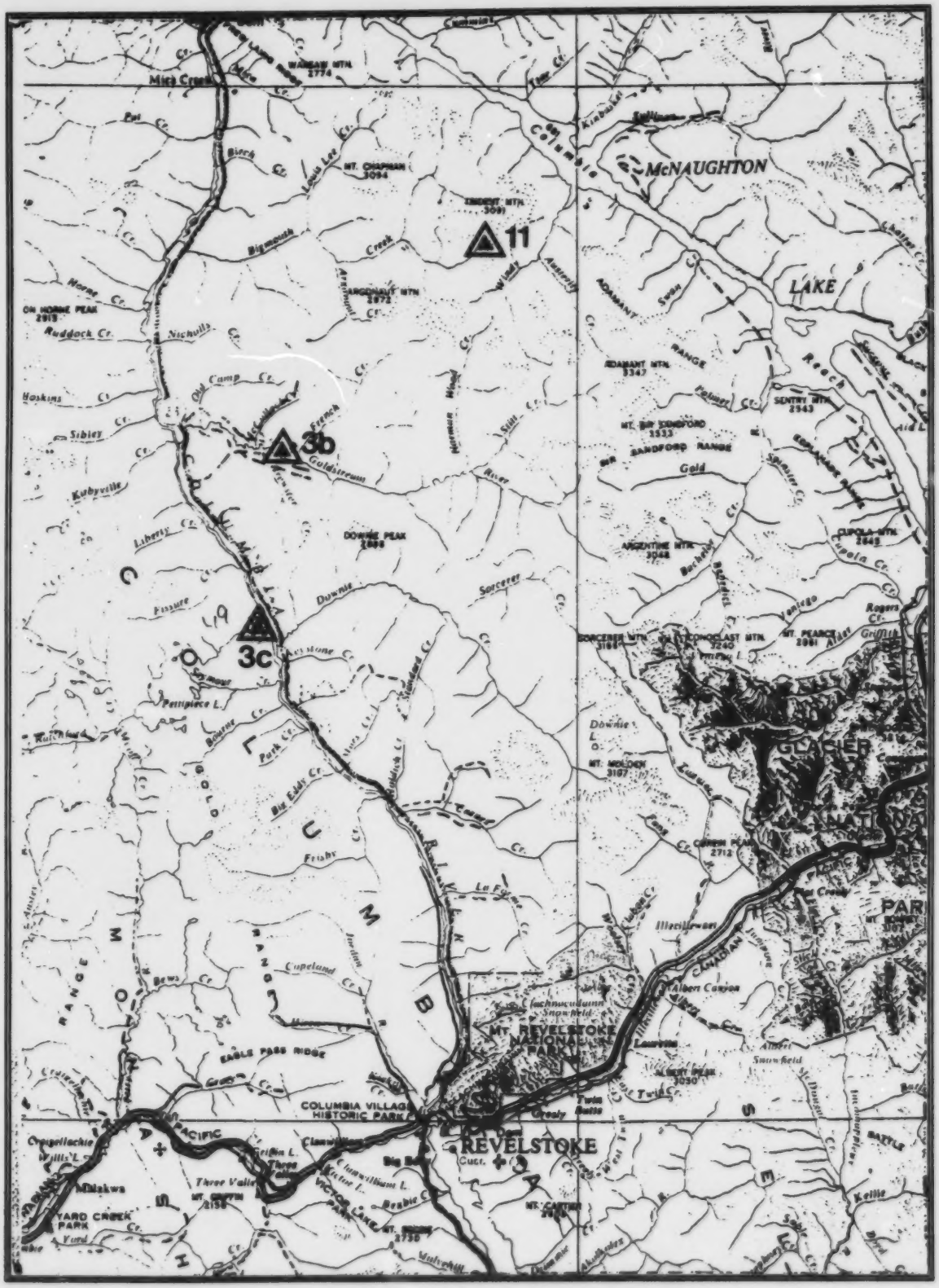


Exhibit A.9 Garnet and Nepheline Syenite Sites

Appendix B

Marine Charts

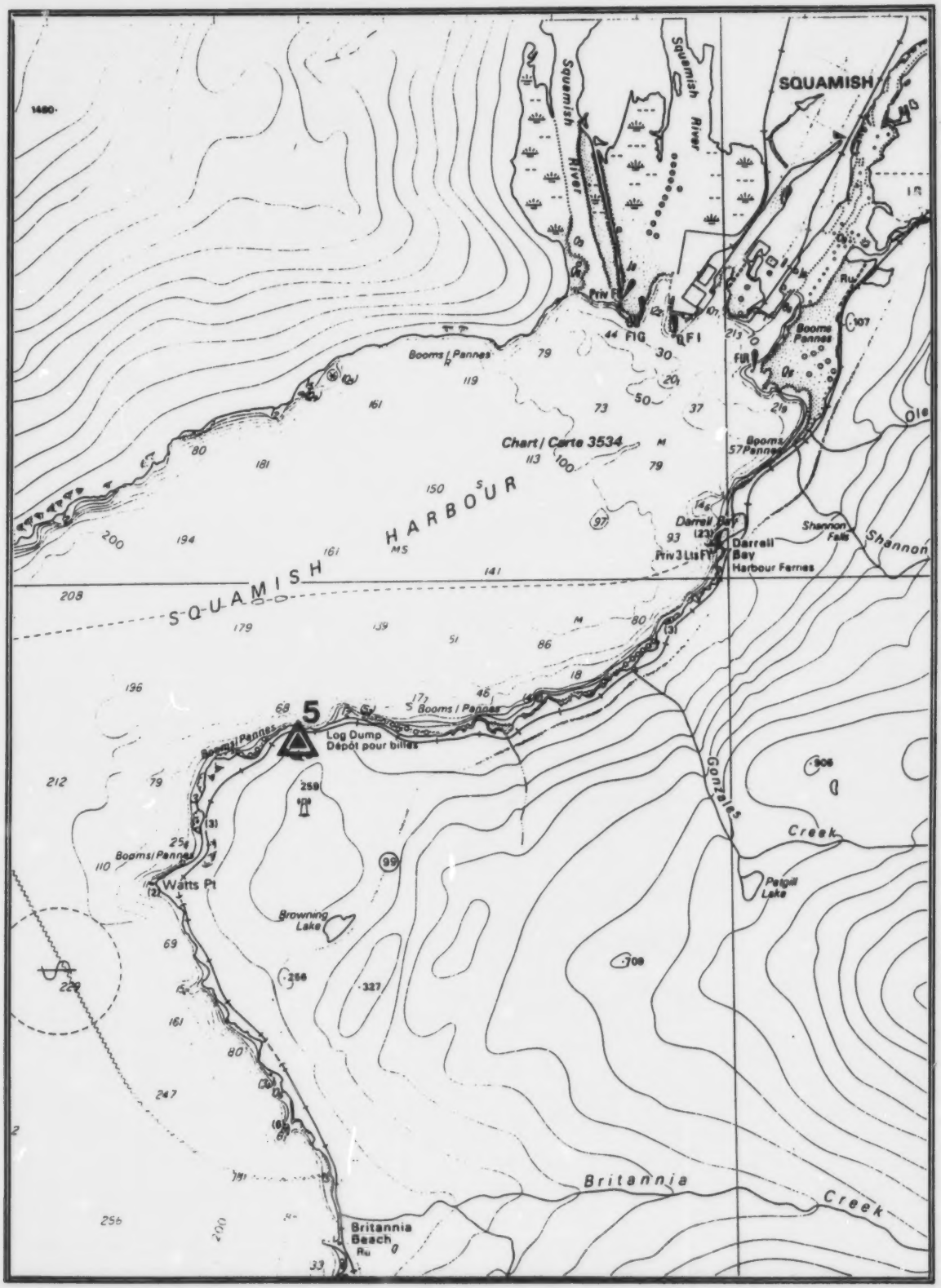


Exhibit B.1 Squamish Harbour

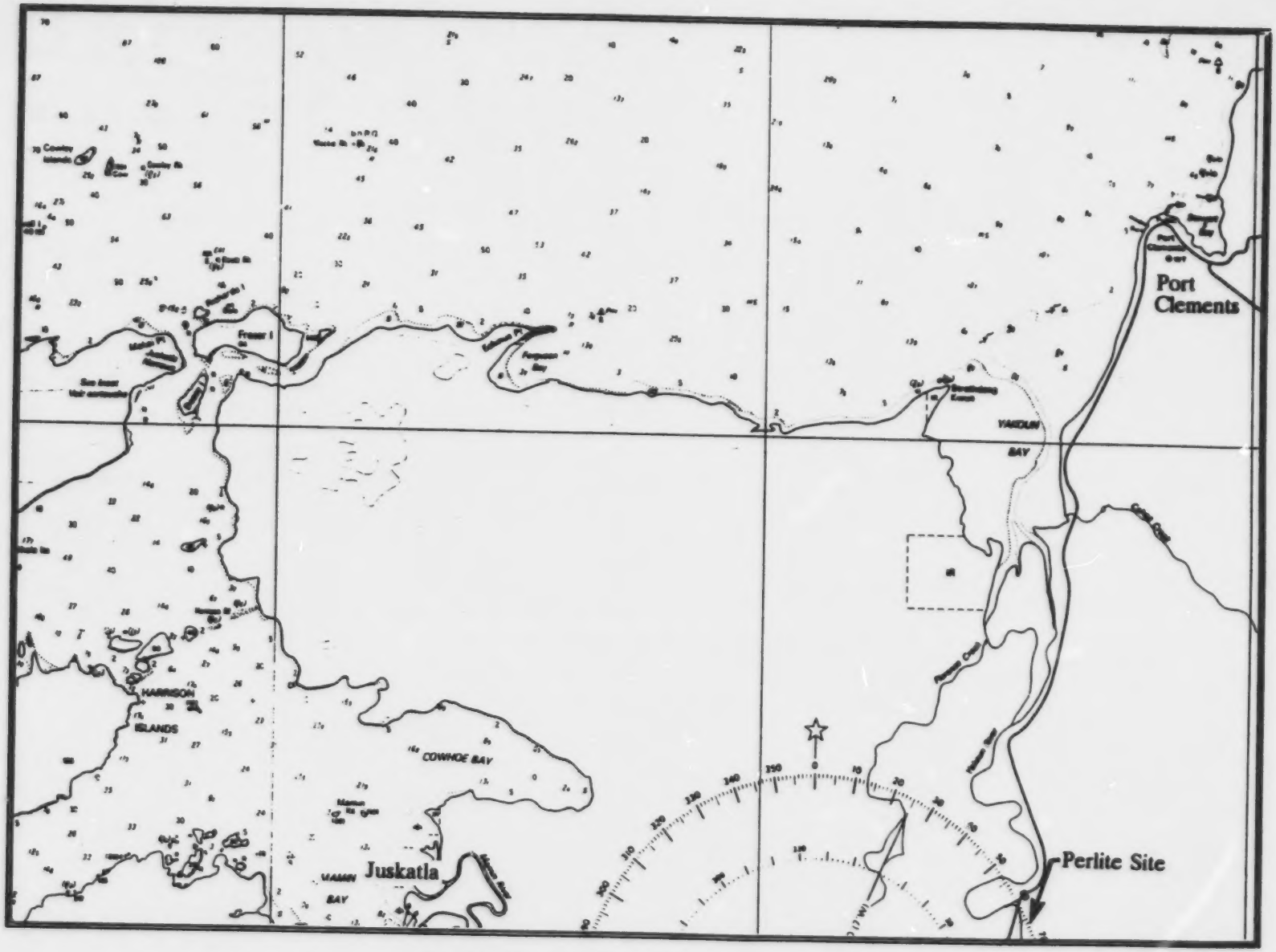


Exhibit B.2 Juskatla and Port Clements

Appendix C

Product Characteristics

Mineral Uses and Characteristics

Perlite

- Perlite is usually crushed and graded on site.
- It is handled in bulk form in the same way as common aggregate, using front-end loaders or conveyors. The raw ore is shipped to distribution centres for crushing, screening, and expansion into a light-weight product.
- The mineral has a specific gravity of 2.3 to 2.8.
- The material can be stored and handled in the open.
- Perlite's uses are mainly related to its low sound transmission and heat resistance properties and low thermal conductivity once it has been expanded by heat. Uses include:
  - aggregate for plasterboard and concrete
  - horticultural aggregate
  - insulation
  - filler in paints, plastics, etc.

Mica

- Mica has a specific gravity of 2.7 to 3.3 and is used as a filler in a variety of industrial products. The mineral has a bulk density of 0.5 to 0.65 tonnes per cubic metre. In flake form, mica has a bulk density of 0.25 to 0.35 tonnes per cubic metre. As a ground product, its bulk density is 0.20 to 0.25 tonnes per cubic metre.
- It can be stored and handled in the open, without a need for protection from the weather.
- Uses for mica include:
  - manufacture of construction materials such as roofing, wall joint cement, paints, and plastics.
- Mica is usually shipped in bagged form, either in small bags (similar to cement) or "maxi" bags, which are roughly 1.5m x 1.5m x 1.5m and hold 1.5 to 2 tonnes of product. For purposes of this study, it is assumed the product is moved in maxi bags.

Garnet

- Garnet has a relatively high specific gravity, in the range of 3.5 to 4.2.
- It is finely crushed and screened on site. One of the primary uses is sand-blasting and the west coast ship building industry is a potential market. Although garnet is not affected by moisture, product is usually protected from the weather in order to keep the shipping weight as low as possible (i.e. to avoid paying the cost of shipping water). A higher quality garnet is also used in the manufacture of abrasive products, including sandpaper, and for grinding of glass, metals and ceramics.
- For this assessment, product is to be shipped in maxi-bags. Because of its high specific gravity, individual bags would be about 1/3 heavier than mica, with 3 to 4 tonnes per bag.
- Although maxi-bags are made of water-proof material, there may be a need to cover loads with tarpaulins for extra protection.

Silica

- Silica has a specific gravity of 2.7 and would be used to produce ferrosilicon or silicon carbide. As a dry sand, silica has a bulk density of 1.4 to 1.6 tonnes per cubic metre.
- Silica is shipped in bulk and could be transported in open equipment. However, it must be moved in clean trucks or railcars, with no residue of limestone or other product from a previous move.
- Ferrosilicon and silicon carbide have a higher density than silica. Ferrosilicon is moisture-sensitive and must be transported in moisture-proof containers.

Crushed Aggregate

- In order to compete in markets which are under consideration in this study, it would be necessary for this product to be high-quality aggregate which can be sold at a premium.
- Crushed aggregate would have a bulk density of 1.4 to 1.6 tonnes per cubic metre.
- Product would be stored in open piles, reclaimed by bulldozers, and loaded by conveyor across the BC Rail mainline, directly into barges or ships.
- Primary uses include road pavements and structural concrete.

Dimension Stone

- "Dimension stone" is quarried in blocks which are then sawn and finished for use as an architectural finish.
- Blocks would typically be 4 to 6 cubic metres in volume, weighing 10 to 20 tonnes each.
- Finished product takes the form slabs which are packed in 5-tonne crates for shipment.

Olivine

- Olivine is a relatively heavy mineral with a specific gravity of 3.2 to 3.6, and a bulk density of 1.6 tonnes per cubic metre.
- It is used for refractory products, beehive incinerators and sand blasting and as a medium for heat storage.
- Material would be crushed to 2" - 4" aggregate before shipping and requires no special handling or storage procedures.

Bentonite

- Bentonite is used as a drilling mud and sealing agent and is generally used in slurry form. Specific gravity is about 2. The bulk density of crude bentonite is generally in the range of 0.55 to 0.65 tonnes per cubic metre, although density can vary widely. Once processed, it has a bulk density of 0.80 to 0.95 tonnes per cubic metre.
- Processing includes drying and grinding. For purposes of this study, it is assumed that product is shipped in 50 kg. or 100 kg. bags on pallets.

Wollastonite

- Wollastonite has a specific gravity of about 2.8; in a dry powder form it has a bulk density of 0.50 to 0.80 tonnes per cubic metre.
- Its main use is in manufacture of ceramics, especially wall and floor tiles. It is also used as a filler in paint, adhesives, glazes, etc. and is considered to be a potential replacement for short-fibre asbestos in a variety of applications.
- It is produced as a fine-grained product and would be shipped in maxi-bags.

Feldspar

- Feldspar is similar to wollastonite in terms of specific gravity. Bulk density varies as follows:

1/2 " screenings	1.1 - 1.4 tonnes per cubic metre
1 1/2" - 3" screenings	1.4 - 1.8 tonnes per cubic metre
200 mesh screenings	1.6 tonnes per cubic metre

- It is used in glass, ceramics and chemical fillers.
- It would be shipped in maxi-bags.

Nepheline Syenite

- Nepheline syenite is used as a sand which is mixed with silica in glass production. It is also used as a filler in paint, plastic and other products.
- It has a specific gravity of about 2.8 with a bulk density of 1.45 to 1.70 tonnes per cubic metre. Product would be shipped in maxi-bags.

Talc

- B.C. pulp mills provide a potential market for talc. (It is used as part of the slurry for pulp processing.) Other uses include manufacture of paints and ceramics as well as a filler for paint, plastic and rubber.
- It has a specific gravity of about 2.8 and bulk density is 1.30 to 1.45 tonnes per cubic metre for 1/2-inch screenings and 1.35 to 1.50 tonnes per cubic foot for 1 1/2" to 3" lumps.
- For most applications, talc must be protected from contamination; and product would be shipped in maxi-bags.

Appendix D

Transportation Costs

Exhibit D.1 Time and Distance for Truck Hauls

Case	Product Handling	Destination	Load/ Unload Time (Hrs.)	Time on Gravel Road (Hrs.)	Distance on Gravel Road (Kms.)	Time on Paved Road (Hrs.)	Distance on Paved Road (Kms.)	Total Distance (Kms.)	Total Time (Hrs.)
1. PERLITE									
a. Empire Valley									
Via Williams L.	1/4-inch aggregate, bulk.	All-truck:							
		Vancouver	1.5	2.2	108	7.4	595	703	11
		Calgary	1.5	2.2	108	11.6	933	1041	15
		Edmonton	1.5	2.2	108	11.8	953	1061	16
		Regina	1.5	2.2	108	21.2	1703	1811	25
		Winnipeg	1.5	2.2	108	28.2	2266	2374	32
		Toronto	1.5	2.2	108	55.7	4484	4592	59
		Montreal	1.5	2.2	108	59.1	4757	4865	63
		Seattle	1.5	2.2	108	8.8	710	818	13
		Portland	1.5	2.2	108	12.3	990	1098	16
		Truck/marine:							
		Seattle	1.5	2.2	108	7.4	595	703	11
		Portland	1.5	2.2	108	7.4	595	703	11
Via Stockpile and Clinton	1/4-inch aggregate, bulk.	To stockpile	0.3	1.4	66	0.0	0	66	2
		Stockpile to:							
		Vancouver	1.5	1.4	66	4.3	349	415	7
		Calgary	1.5	1.4	66	9.0	727	793	12
		Edmonton	1.5	1.4	66	10.6	850	916	13
		Regina	1.5	1.4	66	18.6	1497	1563	21
		Winnipeg	1.5	1.4	66	25.6	2060	2126	28
		Toronto	1.5	1.4	66	53.2	4279	4345	56
		Montreal	1.5	1.4	66	56.6	4552	4618	59
b. Grahan Island	1/4-inch aggregate, bulk.	Vancouver	0.5	0.5	25	0.0	0	25	1
		Seattle	0.5	0.5	25	0.0	0	25	1
		Portland	0.5	0.5	25	0.0	0	25	1
		San Francisco	0.5	0.5	25	0.0	0	25	1
2. MICA - Chase	Maxi-bags	All-truck:							
		Vancouver	2.0	0.5	22	5.4	433	455	8
		Seattle	2.0	0.5	22	6.8	548	570	9
		San Francisco	2.0	0.5	22	22.6	1815	1837	25
		Los Angeles	2.0	0.5	22	29.5	2376	2398	32
		Truck/marine:							
		Seattle	2.0	0.5	22	5.4	433	455	8
		San Francisco	2.0	0.5	22	5.4	433	455	8
		Los Angeles	2.0	0.5	22	5.4	433	455	8
		Japan	2.0	0.5	22	5.4	433	455	8

Case	Product Handling	Destination	Load/ Unload Time (Hrs.)	Time on Gravel Road (Hrs.)	Distance on Gravel Road (Kms.)	Time on Paved Road (Hrs.)	Distance on Paved Road (Kms.)	Total Distance (Kms.)	Total Time (Hrs.)
3. GARNET									
a. Apex/Penticton	Maxi-bags	All-truck:							
		Vancouver	2.0	0.0	2	5.2	421	423	7
		Calgary	2.0	0.0	2	8.5	685	687	11
		Edmonton	2.0	0.0	2	12.5	1005	1007	15
		Winnipeg	2.0	0.0	2	25.1	2018	2020	27
		Seattle	2.0	0.0	2	6.7	537	539	9
		Portland	2.0	0.0	2	10.2	817	819	12
		Los Angeles	2.0	0.0	2	29.4	2365	2367	31
		San Diego	2.0	0.0	2	31.9	2570	2572	34
		Truck/marine:							
		Seattle	2.0	0.0	2	5.2	421	423	7
		Portland	2.0	0.0	2	5.2	421	423	7
		Los Angeles	2.0	0.0	2	5.2	421	423	7
		San Diego	2.0	0.0	2	5.2	421	423	7
b. Revelstoke Site 1	50 kg. bags	All-truck:							
		Seattle	2.0	0.3	14	9.5	766	780	12
		Portland	2.0	0.3	14	13.0	1046	1060	15
		Los Angeles	2.0	0.3	14	32.3	2595	2609	35
		Truck/marine:							
		Seattle	2.0	0.3	14	8.1	653	667	10
		Portland	2.0	0.3	14	8.1	653	667	10
		Los Angeles	2.0	0.3	14	8.1	653	667	10
c. Revelstoke Site 2	50 kg. bags	All-truck:							
		Seattle	2.0	0.1	3	9.5	766	769	12
		Portland	2.0	0.1	3	13.0	1046	1049	15
		Los Angeles	2.0	0.1	3	32.3	2595	2598	34
		Truck/marine:							
		Seattle	2.0	0.1	3	7.9	633	636	10
		Portland	2.0	0.1	3	7.9	633	636	10
		Los Angeles	2.0	0.1	3	7.9	633	636	10
4. SILICA - SILICON CARBIDE									
a. Silica - Longworth	4-inch aggregate, bulk raw ore.	Prince George	1.0	1.0	48	0.9	73	121	3
		Kitimat	1.0	1.0	48	8.7	704	752	11
b. Silicon Carbide - Prince George	Maxi-bags	Japan	1.0	0.0	0	7.8	631	631	9
		Korea	1.0	0.0	0	7.8	631	631	9

Case	Product Handling	Destination	Load/ Unload Time (Hrs.)	Time on Gravel Road (Hrs.)	Distance on Gravel Road (Kms.)	Time on Paved Road (Hrs.)	Distance on Paved Road (Kms.)	Total Distance (Kms.)	Total Time (Hrs.)
c. Silicon Carbide									
- Kitimat	Maxi-bags	Japan	0.0	0.0	0	0.0	0	0	0
		Korea	0.0	0.0	0	0.0	0	0	0
5. CRUSHED AGGREGATE									
- Squamish	Bulk	San Francisco	0.0	0.0	0	0.0	0	0	0
		Japan	0.0	0.0	0	0.0	0	0	0
6. DIMENSION STONE									
a. Site 1	10 - 20 tonne blks.	Vancouver	2.0	0.0	2	2.9	232	234	5
Duffy Lake		Winnipeg	2.0	0.0	2	31.3	2519	2521	33
		Montreal	2.0	0.0	2	62.3	5011	5013	64
		Minneapolis	2.0	0.0	2	38.6	3106	3108	41
		Japan	2.0	0.0	2	2.9	232	234	5
b. Site 2	10 - 20 tonne blks.	Vancouver	2.0	0.1	4	0.9	75	79	3
Squamish		Winnipeg	2.0	0.1	4	29.4	2362	2366	31
		Montreal	2.0	0.1	4	60.3	4854	4858	62
		Minneapolis	2.0	0.1	4	36.6	2947	[illegible]	39
		Japan	2.0	0.1	4	0.9	75	79	3
c. Vancouver	5-tonne crates	All-truck:							
		Calgary	2.0	0.0	0	12.2	978	978	14
		Regina	2.0	0.0	0	21.4	1723	1723	23
		Toronto	2.0	0.0	0	56.0	4506	4506	58
		Seattle	2.0	0.0	0	2.6	212	212	5
		Los Angeles	2.0	0.0	0	25.4	2040	2040	27
		Denver	2.0	0.0	0	29.5	2370	2370	31
		Houston	2.0	0.0	0	50.0	4025	4025	52
		All-marine:							
		Seattle	2.0	0.0	0	0.1	10	10	2
		Los Angeles	2.0	0.0	0	0.1	10	10	2
		Hawaii	2.0	0.0	0	0.1	10	10	2
		Japan	2.0	0.0	0	0.1	10	10	2
7. OLIVINE									
- Princeton	Bulk,	Prince George	1.0	0.2	12	8.4	672	684	10
	2" - 4" aggregate	Edmonton	1.0	0.2	12	13.8	1113	1125	15
		Regina	1.0	0.2	12	19.4	1563	1575	21
		Winnipeg	1.0	0.2	12	26.4	2127	2139	28

Case	Product Handling	Destination	Load/ Unload Time (Hrs.)	Time on Gravel Road (Hrs.)	Distance on Gravel Road (Kms.)	Time on Paved Road (Hrs.)	Distance on Paved Road (Kms.)	Total Distance (Kms.)	Total Time (Hrs.)
8. BENTONITE									
- Hat Creek	50 - 100 Kg. bags	Vancouver	2.0	0.1	6	4.7	377	383	7
		Calgary	2.0	0.1	6	8.0	643	649	10
		Edmonton	2.0	0.1	6	10.7	862	868	13
9. WOLLASTONITE									
- Kelowna	Maxi-bags	All-truck:							
		Vancouver	2.0	0.2	12	6.2	499	511	8
		Calgary	2.0	0.2	12	7.0	560	572	9
		Winnipeg	2.0	0.2	12	23.5	1894	1906	26
		Seattle	2.0	0.2	12	7.7	619	631	10
		Portland	2.0	0.2	12	11.2	899	911	13
		Truck/marine:							
		Seattle	2.0	0.2	12	6.2	499	511	8
		Portland	2.0	0.2	12	6.2	499	511	8
10. FELDSPAR									
- Lumby	Maxi-bags	Redcliff, Alta.	2.0	0.1	4	10.6	849	853	13
		Sacramento	2.0	0.1	4	22.5	1813	1817	25
		Chehalis, Wash.	2.0	0.1	4	9.2	738	742	11
11. NEPHELINE SYENITE									
- Revelstoke via Columbia River west	Maxi-bags	Redcliff, Alta.	2.0	0.8	40	9.8	785	825	13
		Winnipeg	2.0	0.8	40	22.8	1836	1876	26
		Chehalis, Wash.	2.0	0.8	40	11.6	935	975	14
		Sacramento	2.0	0.8	40	25.0	2010	2050	28
		Los Angeles	2.0	0.8	40	32.6	2625	2665	35
		Denver	2.0	0.8	40	28.5	2296	2336	31
		Dallas	2.0	0.8	40	45.9	3693	3733	49
		Houston	2.0	0.8	40	49.3	3967	4007	52
		Truck/marine:							
		Los Angeles	2.0	0.8	40	8.5	683	723	11
		Japan	2.0	0.8	40	8.5	683	723	11
via Columbia River east	Maxi-bags	Redcliff, Alta.	2.0	1.9	90	8.5	681	771	12
		Winnipeg	2.0	1.9	90	21.5	1732	1822	25
		Denver	2.0	1.9	90	15.6	1256	1346	19
		Dallas	2.0	1.9	90	26.5	2129	2219	30
		Houston	2.0	1.9	90	28.5	2294	2384	32

Case	Product Handling	Destination	Load/ Unload Time (Hrs.)	Time on Gravel Road (Hrs.)	Distance on Gravel Road (Kms.)	Time on Paved Road (Hrs.)	Distance on Paved Road (Kms.)	Total Distance (Kms.)	Total Time (Hrs.)
12. TALC - Quesnel	Maxi-bags	All-truck:							
		Vancouver	2.0	0.4	18	8.7	703	721	11
		Seattle	2.0	0.4	18	10.2	822	840	13
		Portland	2.0	0.4	18	13.7	1102	1120	16
		Truck/marine:							
		Seattle	2.0	0.4	18	8.7	703	721	11
		Portland	2.0	0.4	18	8.7	703	721	11

Exhibit D.2 Trucking Costs

Case	Product Handling	Destination	Equip. Type	Payload (Tonnes)	Cost With No Backhaul (Dollars)	($/tonne)
1. PERLITE						
a. Empire Valley						
Via Williams L.	1/4-inch aggregate, bulk.	All-truck:				
		Vancouver	Bulk	40.1	1,208	30
		Calgary	Bulk	40.1	1,731	43
		Edmonton	Bulk	40.1	1,751	44
		Regina	Bulk	40.1	2,997	75
		Winnipeg	Bulk	40.1	3,954	99
		Toronto	Bulk	40.1	7,663	191
		Montreal	Bulk	40.1	8,146	203
		Seattle	Bulk	25.6	1,426	56
		Portland	Bulk	25.6	1,856	72
		Truck/marine:				
		Seattle	Bulk	40.1	1,208	30
		Portland	Bulk	40.1	1,208	30
Via Stockpile and Clinton	1/4-inch aggregate, bulk.	To stockpile	Bulk	8.5	90	11
		Stockpile to:				
		Vancouver	Bulk	40.1	740	18
		Calgary	Bulk	40.1	1,326	33
		Edmonton	Bulk	40.1	1,507	38
		Regina	Bulk	40.1	2,583	64
		Winnipeg	Bulk	40.1	3,535	88
		Toronto	Bulk	40.1	7,243	181
		Montreal	Bulk	40.1	7,724	193
b. Graham Island	1/4-inch aggregate, bulk.	Vancouver	Bulk	13.0	85	7
		Seattle	Bulk	13.0	85	7
		Portland	Bulk	13.0	85	7
		San Francisco	Bulk	13.0	85	7
2. MICA - Chase	Maxi-bags	All-truck:				
		Vancouver	Flat/van	44.9	827	18
		Seattle	Flat/van	30.5	1,035	34
		San Francisco	Flat/van	21.4	2,645	124
		Los Angeles	Flat/van	21.4	3,433	160
		Truck/marine:				
		Seattle	Flat/van	44.9	827	18
		San Francisco	Flat/van	44.9	827	18
		Los Angeles	Flat/van	44.9	827	18
		Japan	Flat/van	44.9	827	18

Case	Product Handling	Destination	Equip. Type	Payload (Tonnes)	Cost With No Backhaul (Dollars)	($/tonne)
3. GARNET						
a. Apex/Penticton	Maxi-bags	All-truck:				
		Vancouver	Flat/van	44.9	768	17
		Calgary	Flat/van	44.9	1,185	26
		Edmonton	Flat/van	44.9	1,687	38
		Winnipeg	Flat/van	44.9	3,443	77
		Seattle	Flat/van	30.5	953	31
		Portland	Flat/van	30.5	1,386	45
		Los Angeles	Flat/van	21.4	3,356	157
		San Diego	Flat/van	21.4	3,643	170
		Truck/marine:				
		Seattle	Flat/van	44.9	768	17
		Portland	Flat/van	44.9	768	17
		Los Angeles	Flat/van	44.9	768	17
		San Diego	Flat/van	44.9	768	17
b. Revelstoke Site 1	50 kg. bags	All-truck:				
		Seattle	Flat/van	30.5	1,388	46
		Portland	Flat/van	30.5	1,832	60
		Los Angeles	Flat/van	21.4	3,722	174
		Truck/marine:				
		Seattle	Flat/van	44.9	1,163	26
		Portland	Flat/van	44.9	1,163	26
		Los Angeles	Flat/van	44.9	1,163	26
c. Revelstoke Site 2	50 kg. bags	All-truck:				
		Seattle	Flat/van	30.5	1,365	45
		Portland	Flat/van	30.5	1,796	59
		Los Angeles	Flat/van	21.4	3,702	173
		Truck/marine:				
		Seattle	Flat/van	44.9	1,110	25
		Portland	Flat/van	44.9	1,110	25
		Los Angeles	Flat/van	44.9	1,110	25
4. SILICA - SILICON CARBIDE						
a. Silica - Longworth	4-inch aggregate, bulk raw ore.	Prince George	Bulk	40.1	271	7
		Kitimat	Bulk	40.1	1,262	31
b. Silicon Carbide - Prince George	Maxi-bags	Japan	Flat	40.0	1,080	27
		Korea	Flat	40.0	1,080	27

Case	Product Handling	Destination	Equip. Type	Payload (Tonnes)	Cost With No Backhaul (Dollars)	Cost With No Backhaul ($/tonne)
c. Silicon Carbide						
- Kitimat	Maxi-bags	Japan	None	n.a.	n.a.	n.a.
		Korea	None	n.a.	n.a.	n.a.
5. CRUSHED AGGREGATE						
- Squamish	Bulk	San Francisco	None	n.a.	n.a.	n.a.
		Japan	None	n.a.	n.a.	n.a.
6. DIMENSION STONE						
a. Site 1	10 - 20 tonne blks.	Vancouver	Flat	44.9	462	10
Duffy Lake		Winnipeg	Flat	44.9	4,274	95
		Montreal	Flat	44.9	8,565	191
		Minneapolis	Flat	21.4	4,395	205
		Japan	Flat	44.9	462	10
b. Site 2	10 - 20 tonne blks.	Vancouver	Flat	44.9	213	5
Squamish		Winnipeg	Flat	44.9	4,017	89
		Montreal	Flat	44.9	8,306	185
		Minneapolis	Flat	21.4	4,165	195
		Japan	Flat	44.9	213	5
c. Vancouver	5-tonne crates	All-truck:				
		Calgary	Flat/van	44.9	1,633	37
		Regina	Flat/van	44.9	2,907	65
		Toronto	Flat/van	44.9	7,680	171
		Seattle	Flat/van	30.5	405	13
		Los Angeles	Flat/van	21.4	2,901	136
		Denver	Flat/van	21.4	3,355	157
		Houston	Flat/van	21.4	5,636	263
		All-marine:				
		Seattle	Flat/van	44.9	115	3
		Los Angeles	Flat/van	44.9	115	3
		Hawaii	Flat/van	44.9	115	3
		Japan	Flat/van	44.9	115	3
7. OLIVINE						
- Princeton	Bulk,	Prince George	Bulk	40.1	1,142	28
	2" - 4" aggregate	Edmonton	Bulk	40.1	1,879	47
		Regina	Bulk	40.1	2,581	64
		Winnipeg	Bulk	40.1	3,533	88

Case	Product Handling	Destination	Equip. Type	Payload (Tonnes)	Cost With No Backhaul (Dollars)	($/tonne)
8. BENTONITE						
- Hat Creek	50 - 100 Kg. bags	Vancouver	Flat/van	44.9	704	16
		Calgary	Flat/van	44.9	1,124	25
		Edmonton	Flat/van	44.9	1,467	33
9. WOLLASTONITE						
- Kelowna	Maxi-bags	All-truck:				
		Vancouver	Flat/van	44.9	913	20
		Calgary	Flat/van	44.9	1,002	22
		Winnipeg	Flat/van	44.9	3,253	72
		Seattle	Flat/van	30.5	1,106	36
		Portland	Flat/van	30.5	1,537	50
		Truck/marine:				
		Seattle	Flat/van	44.9	913	20
		Portland	Flat/van	44.9	913	20
10. FELDSPAR						
- Lumby	Maxi-bags	Redcliff, Alta.	Flat/van	44.9	1,440	32
		Sacramento	Flat/van	21.4	2,616	122
		Chehalis, Wash.	Flat/van	30.5	1,304	43
11. NEPHELINE SYENITE						
- Revelstoke via Columbia River west	Maxi-bags	Redcliff, Alta.	Flat/van	44.9	1,410	31
		Winnipeg	Flat/van	44.9	3,216	72
		Chehalis, Wash.	Flat/van	30.5	1,712	56
		Sacramento	Flat/van	21.4	2,970	139
		Los Angeles	Flat/van	21.4	3,813	178
		Denver	Flat/van	21.4	3,368	157
		Dallas	Flat/van	21.4	5,282	247
		Houston	Flat/van	21.4	5,658	264
		Truck/marine:				
		Los Angeles	Flat/van	44.9	1,264	28
		Japan	Flat/van	44.9	1,264	28
via Columbia River east	Maxi-bags	Redcliff, Alta.	Flat/van	44.9	1,339	30
		Winnipeg	Flat/van	44.9	3,143	70
		Denver	Flat/van	21.4	3,133	146
		Dallas	Flat/van	21.4	5,048	236
		Houston	Flat/van	21.4	5,423	253

Case	Product Handling	Destination	Equip. Type	Payload (Tonnes)	Cost With No Backhaul (Dollars)	Cost With No Backhaul ($/tonne)
12. TALC - Quesnel	Maxi-bags	All-truck:				
		Vancouver	Flat/van	44.9	1,253	28
		Seattle	Flat/van	30.5	1,490	49
		Portland	Flat/van	30.5	1,921	63
		Truck/marine:				
		Seattle	Flat/van	44.9	1,253	28
		Portland	Flat/van	44.9	1,253	28

Exhibit D.3 Marine Costs

Case	Product Handling	Destination	Load/ Unload Time (Days)	Transit Time (Days)	One-way Transit Distance (Kms.)	Equip. Type	Equip. Capacity (Tonnes)	Marine Cost (Dollars)	Marine Cost ($/Tonne)
1. PERLITE									
a. Empire Valley									
Via Williams L.	1/4-inch aggregate, bulk.	All-truck:							
		Vancouver	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Calgary	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Edmonton	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Regina	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Winnipeg	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Toronto	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Montreal	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Seattle	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Portland	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Truck/marine:							
		Seattle	4.0	1.1	234	Barge	5000	63000	16
		Portland	4.0	3.1	673	Barge	3000	87000	29
Via Stockpile and Clinton	1/4-inch aggregate, bulk.	To stockpile	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Stockpile to:.							
		Vancouver	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Calgary	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Edmonton	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Regina	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Winnipeg	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Toronto	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Montreal	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
b. Grahan Island	1/4-inch aggregate, bulk.	Vancouver	4.0	4.5	991	Barge	3000	59000	20
		Seattle	5.3	5.3	1179	Barge	5000	95000	24
		Portland	4.0	8.3	1392	Barge	3000	88000	29
		San Francisco	4.0	9.8	2166	Barge	3000	120000	40
2. MICA - Chase	Maxi-bags	All-truck:							
		Vancouver	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Seattle	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		San Francisco	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Los Angeles	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Truck/marine:							
		Seattle	4.0	1.1	234	Barge	3000	40000	20
		San Francisco	6.5	6.8	1505	Barge	5000	119000	24
		Los Angeles	4.0	9.7	2153	Barge	3000	118000	39
		Japan	n.a.	16.1	7895	Container	1800 TEU	190/cont.	10

Case	Product Handling	Destination	Load/ Unload Time (Days)	Transit Time (Days)	One-way Transit Distance (Kms.)	Equip. Type	Equip. Capacity (Tonnes)	Marine Cost (Dollars)	Marine Cost ($/Tonne)
3. GARNET									
a. Apex/Penticton	Maxi-bags	All-truck:							
		Vancouver	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Calgary	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Edmonton	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Winnipeg	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Seattle	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Portland	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Los Angeles	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		San Diego	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Truck/marine:							
		Seattle	6.5	1.1	234	Barge	5000	63000	16
		Portland	6.5	3.1	673	Barge	5000	83000	21
		Los Angeles	6.5	9.7	2153	Barge	5000	148000	30
		San Diego	6.5	10.2	2270	Barge	5000	152000	30
b. Revelstoke Site 1	50 kg. bags	All-truck:							
		Seattle	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Portland	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Los Angeles	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Truck/marine:							
		Seattle	4.0	1.1	234	Barge	3000	40000	20
		Portland	4.0	3.1	673	Barge	3000	58000	29
		Los Angeles	2.8	9.7	2153	Barge	3000	110000	55
c. Revelstoke Site 2	50 kg. bags	All-truck:							
		Seattle	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Portland	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Los Angeles	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Truck/marine:							
		Seattle	4.0	1.1	234	Barge	3000	40000	20
		Portland	4.0	3.1	673	Barge	3000	58000	29
		Los Angeles	2.8	9.7	2153	Barge	3000	110000	55
4. SILICA - SILICON CARBIDE									
a. Silica - Longworth	4-inch aggregate, bulk raw ore.	Prince George	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Kitimat	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
b. Silicon Carbide - Prince George	Maxi-bags	Japan	3.8	10.1	8095	Multi-ppse	16000 DWT	n.a.	18
		Korea	3.8	11.0	8783	Multi-ppse	16000 DWT	n.a.	19

Case	Product Handling	Destination	Load/ Unload Time (Days)	Transit Time (Days)	One-way Transit Distance (Kms.)	Equip. Type	Equip. Capacity (Tonnes)	Marine Cost (Dollars)	Marine Cost ($/Tonne)
c. Silicon Carbide									
- Kitimat	Maxi-bags	Japan	3.0	10.1	8095	Multi-pps	16000 DWT	n.a.	18
		Korea	3.0	11.0	8783	Multi-pps	16000 DWT	n.a.	19
5. CRUSHED AGGREGATE									
- Squamish	Bulk	San Francisco	4.0	4.4	1359	Bulk	60000 DWT	n.a.	3
		Japan	4.0	22.4	7949	Bulk	60000 DWT	n.a.	10
6. DIMENSION STONE									
a. Site 1	10 - 20 tonne blks.	Vancouver	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Duffy Lake		Winnipeg	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Montreal	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Minneapolis	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Japan	n.a.	19.7	7895	Multi-pps	16000 DWT	n.a.	15
b. Site 2	10 - 20 tonne blks.	Vancouver	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Squamish		Winnipeg	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Montreal	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Minneapolis	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Japan	n.a.	19.7	7895	Multi-pps	16000 DWT	n.a.	15
c. Vancouver	5-tonne crates	All-truck:							
		Calgary	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Regina	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Toronto	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Seattle	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Los Angeles	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Denver	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Houston	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		All-marine:							
		Seattle	4.0	1.1	234	Barge	3000	40000	20
		Los Angeles	2.0	9.7	2153	Barge	3000	110000	55
		Hawaii	n.a.	5.6	4483	Multi-pps	16000 DWT	n.a.	12
		Japan	n.a.	19.7	7895	Multi-pps	16000 DWT	n.a.	15
7. OLIVINE									
- Princeton	Bulk,	Prince George	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	2" - 4" aggregate	Edmonton	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Regina	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Winnipeg	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Case	Product Handling	Destination	Load/ Unload Time (Days)	Transit Time (Days)	One-way Transit Distance (Kms.)	Equip. Type	Equip. Capacity (Tonnes)	Marine Cost (Dollars)	Marine Cost ($/Tonne)
8. BENTONITE									
- Hat Creek	50 - 100 Kg. bags	Vancouver	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Calgary	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Edmonton	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
9. WOLLASTONITE									
- Kelowna	Maxi-bags	All-truck:							
		Vancouver	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Calgary	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Winnipeg	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Seattle	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Portland	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Truck/marine:							
		Seattle	4.0	1.1	234	Barge	3000	40000	20
		Portland	4.0	3.1	673	Barge	3000	58000	29
10. FELDSPAR									
- Lumby	Maxi-bags	Redcliff, Alta.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Sacramento	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Chehalis, Wash.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
11. NEPHELINE SYENITE									
- Revelstoke via Columbia River west	Maxi-bags	Redcliff, Alta.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Winnipeg	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Chehalis, Wash.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Sacramento	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Los Angeles	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Denver	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Dallas	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Houston	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Truck/marine:							
		Los Angeles	6.5	9.7	2153	Barge	5000	148000	30
		Japan	n.a.	16.1	7895	Container	1800 TEU	190/TEU	10
via Columbia River east	Maxi-bags	Redcliff, Alta.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Winnipeg	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Denver	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Dallas	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Houston	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Case	Product Handling	Destination	Load/ Unload Time (Days)	Transit Time (Days)	One-way Transit Distance (Kms.)	Equip. Type	Equip. Capacity (Tonnes)	Marine Cost (Dollars)	Marine Cost ($/Tonne)
12. TALC - Quesnel	Maxi-bags	All-truck:							
		Vancouver	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Seattle	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Portland	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Truck/marine:							
		Seattle	6.5	1.1	234	Barge	5000	79000	16
		Portland	6.5	3.1	673	Barge	5000	103000	21

Exhibit D.4 Total Distribution Costs

Case	Product Handling	Destination	Trucking With No Backhaul ($/Tonne)	Transfer Cost ($/Tonne)	Marine Cost ($/Tonne)	Total Cost ($/Tonne)
1. PERLITE						
a. Empire Valley						
Via Williams L.	1/4-inch aggregate, bulk.	All-truck:				
		Vancouver	30	n.a.	n.a.	30
		Calgary	43	n.a.	n.a.	43
		Edmonton	44	n.a.	n.a.	44
		Regina	75	n.a.	n.a.	75
		Winnipeg	99	n.a.	n.a.	99
		Toronto	191	n.a.	n.a.	191
		Montreal	203	n.a.	n.a.	203
		Seattle	56	n.a.	n.a.	56
		Portland	72	n.a.	n.a.	72
		Truck/marine:				
		Seattle	30	12	16	58
		Portland	30	12	29	71
Via Stockpile and Clinton	1/4-inch aggregate, bulk.	To stockpile	11	0	n.a.	11
		Stockpile to:				
		Vancouver	18	4	n.a.	22
		Calgary	33	4	n.a.	37
		Edmonton	38	4	n.a.	42
		Regina	64	4	n.a.	68
		Winnipeg	88	4	n.a.	92
		Toronto	181	4	n.a.	185
		Montreal	193	4	n.a.	197
b. Graham Island	1/4-inch aggregate, bulk.	Vancouver	7	8	20	34
		Seattle	7	8	24	38
		Portland	7	8	29	44
		San Francisco	7	8	40	54
2. MICA - Chase	Maxi-bags	All-truck:				
		Vancouver	18	n.a.	n.a.	18
		Seattle	34	n.a.	n.a.	34
		San Francisco	124	n.a.	n.a.	124
		Los Angeles	160	n.a.	n.a.	160
		Truck/marine:				
		Seattle	18	12	20	50
		San Francisco	18	12	24	54
		Los Angeles	18	12	39	70
		Japan	18	37	10	65

Case	Product Handling	Destination	Trucking With No Backhaul ($/Tonne)	Transfer Cost ($/Tonne)	Marine Cost ($/Tonne)	Total Cost ($/Tonne)
3. GARNET						
a. Apex/Penticton	Maxi-bags	All-truck:				
		Vancouver	17	n.a.	n.a.	17
		Calgary	26	n.a.	n.a.	26
		Edmonton	38	n.a.	n.a.	38
		Winnipeg	77	n.a.	n.a.	77
		Seattle	31	n.a.	n.a.	31
		Portland	45	n.a.	n.a.	45
		Los Angeles	157	n.a.	n.a.	157
		San Diego	170	n.a.	n.a.	170
		Truck/marine:				
		Seattle	17	12	16	45
		Portland	17	12	21	50
		Los Angeles	17	12	30	59
		San Diego	17	12	30	60
b. Revelstoke Site 1	50 kg. bags	All-truck:				
		Seattle	46	n.a.	n.a.	46
		Portland	60	n.a.	n.a.	60
		Los Angeles	174	n.a.	n.a.	174
		Truck/marine:				
		Seattle	26	12	20	58
		Portland	26	12	29	67
		Los Angeles	26	12	55	93
c. Revelstoke Site 2	50 kg. bags	All-truck:				
		Seattle	45	n.a.	n.a.	45
		Portland	59	n.a.	n.a.	59
		Los Angeles	173	n.a.	n.a.	173
		Truck/marine:				
		Seattle	25	12	20	57
		Portland	25	12	29	66
		Los Angeles	25	12	55	92
4. SILICA - SILICON CARBIDE						
a. Silica - Longworth	4-inch aggregate, bulk raw ore.	Prince George	7	n.a.	n.a.	7
		Kitimat	31	n.a.	n.a.	31
b. Silicon Carbide - Prince George	Maxi-bags	Japan	27	0	18	53
		Korea	27	0	19	54

Case	Product Handling	Destination	Trucking With No Backhaul ($/Tonne)	Transfer Cost ($/Tonne)	Marine Cost ($/Tonne)	Total Cost ($/Tonne)
c. Silicon Carbide						
- Kitimat	Maxi-bags	Japan	n.a.	4	18	22
		Korea	n.a.	4	19	23
5. CRUSHED AGGREGATE						
- Squamish	Bulk	San Francisco	n.a.	n.a.	3	3
		Japan	n.a.	n.a.	10	10
6. DIMENSION STONE						
a. Site 1	10 - 20 tonne blks.	Vancouver	10	n.a.	n.a.	10
Duffy Lake		Winnipeg	95	n.a.	n.a.	95
		Montreal	191	n.a.	n.a.	191
		Minneapolis	205	n.a.	n.a.	205
		Japan	10	8	15	34
b. Site 2	10 - 20 tonne blks.	Vancouver	5	n.a.	n.a.	5
Squamish		Winnipeg	89	n.a.	n.a.	89
		Montreal	185	n.a.	n.a.	185
		Minneapolis	195	n.a.	n.a.	195
		Japan	5	4	15	24
c. Vancouver	5-tonne crates	All-truck:				
		Calgary	37	n.a.	n.a.	37
		Regina	65	n.a.	n.a.	65
		Toronto	171	n.a.	n.a.	171
		Seattle	13	n.a.	n.a.	13
		Los Angeles	136	n.a.	n.a.	136
		Denver	157	n.a.	n.a.	157
		Houston	263	n.a.	n.a.	263
		All-marine:				
		Seattle	3	12	20	34
		Los Angeles	3	12	55	69
		Hawaii	3	12	12	27
		Japan	3	12	15	30
7. OLIVINE						
- Princeton	Bulk,	Prince George	28	n.a.	n.a.	28
	2" - 4" aggregate	Edmonton	47	n.a.	n.a.	47
		Regina	64	n.a.	n.a.	64
		Winnipeg	88	n.a.	n.a.	88

Case	Product Handling	Destination	Trucking With No Backhaul ($/Tonne)	Transfer Cost ($/Tonne)	Marine Cost ($/Tonne)	Total Cost ($/Tonne)
8. BENTONITE						
- Hat Creek	50 - 100 Kg. bags	Vancouver	16	n.a.	n.a.	16
		Calgary	25	n.a.	n.a.	25
		Edmonton	33	n.a.	n.a.	33
9. WOLLASTONITE						
- Kelowna	Maxi-bags	All-truck:				
		Vancouver	20	n.a.	n.a.	20
		Calgary	22	n.a.	n.a.	22
		Winnipeg	72	n.a.	n.a.	72
		Seattle	36	n.a.	n.a.	36
		Portland	50	n.a.	n.a.	50
		Truck/marine:				
		Seattle	20	12	20	52
		Portland	20	12	29	61
10. FELDSPAR						
- Lumby	Maxi-bags	Redcliff, Alta.	32	n.a.	n.a.	32
		Sacramento	122	n.a.	n.a.	122
		Chehalis, Wash.	43	n.a.	n.a.	43
11. NEPHELINE SYENITE						
- Revelstoke via Columbia River west	Maxi-bags	Redcliff, Alta.	31	n.a.	n.a.	31
		Winnipeg	72	n.a.	n.a.	72
		Chehalis, Wash.	56	n.a.	n.a.	56
		Sacramento	139	n.a.	n.a.	139
		Los Angeles	178	n.a.	n.a.	178
		Denver	157	n.a.	n.a.	157
		Dallas	247	n.a.	n.a.	247
		Houston	264	n.a.	n.a.	264
		Truck/marine:				
		Los Angeles	28	12	30	70
		Japan	28	37	10	75
via Columbia River east	Maxi-bags	Redcliff, Alta.	30	n.a.	n.a.	30
		Winnipeg	70	n.a.	n.a.	70
		Denver	146	n.a.	n.a.	146
		Dallas	236	n.a.	n.a.	236
		Houston	253	n.a.	n.a.	253

Case	Product Handling	Destination	Trucking With No Backhaul ($/Tonne)	Transfer Cost ($/Tonne)	Marine Cost ($/Tonne)	Total Cost ($/Tonne)
12. TALC - Quesnel	Maxi-bags	All-truck:				
		Vancouver	28	n.a.	n.a.	28
		Seattle	49	n.a.	n.a.	49
		Portland	63	n.a.	n.a.	63
		Truck/marine:				
		Seattle	28	12	16	56
		Portland	28	12	21	61

Appendix E

Metric Conversion Factors

Metric Conversions

1 tonne	=	2,205 lbs. = 1.102 tons
1 tonne per m^3	=	62.4 lbs. per cubic foot
1 centimetre	=	2.54 inches
1 kilometre	=	0.621 miles
1 kph	=	0.621 mph

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